AN AUDIT OF MANAGEMENT OF THE CROWN FORESTS OF ONTARIO

A report to:

The Hon. V.G. Kerrio
Minister of Natural Resources
Province of Ontario
August 1 1986

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FOREWORD

The audit reported here was carried out under contract to the Hon. V.G. Kerrio, Ontario Minister of Natural Resources. Conducted between January and July of 1986 the audit comprised an extensive review of management on Crown land organised in Management Units. Full support for the audit was provided by the ministry, and there was access to all sources of information requested.

By the nature of the task, the report contains judgements of adequacy and suggestions for revision of procedures in the Ministry with respect to managing the Crown forests. These are offered as professional opinions based on experience in the context of contemporary technical forest management standards.

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AN AUDIT OF MANAGEMENT OF THE CROWN FORESTS OF ONTARIO

I-INTRODUCTION

This audit of management on the Crown forests of Ontario examines adequacy of the management planning process relative to the stated objectives for these forests. The Oxford dictionary defines audit as " To make an official systematic examination of (accounts)". In that context, this audit has been a systematic examination of the technical process of forest management as it is designed and implemented on Crown forests in Ontario. Because of the size and complexity of these forests, and consequent complexity of the management and administrative systems, the audit results are presented in context, albeit abbreviated, rather than as a list of shortcomings. The attempt is to provide sufficient context in the leading paragraphs of each section to facilitate understanding and interpretation of the audit findings, but technical familiartiy with the planning procedures is presumed.

The report contains statements with respect to adequacy, and recommendations for change. These are embodied in the text to ensure interpretation in the same context in which they were reached. Recommendations tend to indicate problem areas that should be examined and resolved by the OMNR, rather than prescribing "fixes". If there is one dominant feature of Crown forest management in Ontario, it is the prevalence of all-purpose solutions to non-specific problems. Therefore one overriding recommendation is **that the OMNR review the issues raised here in their specific contexts, and that solutions be designed that are appropriate to the real problems.**

To be effective, forest management requires continuous attention. With time, the forest changes both naturally and in response to management. The social demands on the forest change over time, and there is a changing understanding of all these interacting dynamics. Forest management must be continually tended in order to be continually consistent in this dynamic situation. It is therefore always possible to improve forest management. This audit can be a positive factor in the continuing process of improving Crown

forest management in Ontario. If the audit initiates contemplative review of the parts of the system questioned, then it will be successful. If it evokes a defensive response within the OMNR, or a destructive response amongst the detractors of the OMNR it will have failed.

APPROACH OF THE AUDIT

The approach to the audit was an intensive review of procedures, and a sampling of the application of those procedures. There are a large number of planning manuals, and procedures associated with those manuals, as well as strategic planning documents in the OMNR. All material identified as related to the forest management planning process was reviewed. Much of this material was discussed with its author. This was to ensure an understanding of the procedures, and of what the authors of the procedures supposed they would accomplish, before attempting evaluation of the procedures, and their application.

Once the basis for management planning was understood, six management units were reviewed for application of the process. These Units were chosen as representative of the different approaches to management organisation (three Crown Management Units and three Forest Management Agreements) the type of forest cover (five in Boreal forest, and one in Great Lakes-St Lawrence forest) and the mix of industry dependent on the Unit for wood supply (primarily the mix of sawmills and pulpmills). The six Units examined were; Plonski Forest Crown Management Unit, Dryden Crown Management Unit, Minden Crown Management Unit, Iroquois Falls Forest Management Agreement, Lake Nipigon Forest Management Agreement, and the English River Forest Management Agreement.

The procedure for these six Units was to examine the Management Plan and Operating Plan for technical consistency, and then meet with the authors (or the person currently responsible for the Unit) on the Management Unit to review the plans. To establish a comprehensive understanding of a plan the review with the author took anywhere from one and one-half to four days depending on the complexity of the plan and the nature of its presentation. During the review of a plan the associated correspondence file for its approval upwards through the administrative hierarchy was also scanned. At each Unit the equivalent of the planning team that integrates the various forest uses into a management plan was assembled to discuss the integration

process.

The concentration was on adequacy of the design process to the management task. The questions posed included: How well does the planning process foresee events and problems? How well does the planning process define these problems? How well does the planning process design solutions to the defined problems, and particularly, are the solutions the necessary and sufficient basis to correct the problem? and, How well does the management process implement the designed solutions? The audit looked for evidence that there was a defined forest, with a defined problem, and a defined responsibility for solving that problem. Further, it assessed the adequacy of understanding of the problems and of solutions in the context of forest dynamics. The proposed tools for implementing the plan were examined for adequacy relative to the logistical task of implementation, and evidence was sought with respect to the manner in which efficacy of management as it occurred in the forest was evaluated, and used as feedback control to improve the overall performance of the management process. For a non-technical overview of forest management, and the role the above issues play in the evaluation of forest management, the reader is directed to the Appendix.

The plans were examined with respect to the interface of timber management planning with the planning for non-timber uses of the forest. It is a relatively straightforward task to review and evaluate the timber management component of a plan. The issues are quantitatively clear, and it is expected that a plan will document a causative link of any proposed action to the expected result. For example, where planting is proposed as part of the solution to a wood supply problem, it is expected that the plan will show how much wood could be produced from the Unit if planting were not carried out, and how much could be produced from the Unit by following a chosen planting regime. The cause-effect relationship with respect to a prescribed treatment is expected to be explicitly quantitative.

In contrast to the situation in timber planning, the non-timber values have no established quantitative cause-effect relationships. There are many broad cause-effect correlations cited but few, if any, are stated in the form "this much of this action will give this much of this result". For example, the notion of habitat diversity and its importance to wildlife populations is well known and frequently referred to in plans. However, one never sees an explicit measure of diversity, and one never sees a quantitative cause-effect

linkage of a measured increase (or decrease) in diversity in relation to a measurable response of a population. No plan says for example, "if five more units of diversity are developed in the forest, there will be two and one half more units of wildlife response". This leaves the issues with respect to the integration of non-timber, and timber, management goals as pure judgements, with no possible measures of effectiveness. No attempt was made to evaluate these judgements, except to understand how the judgements had entered into the timber management planning process in specific cases.

Public expectations with respect to their forests were not examined. The audit has concentrated on the technical application of resource management to the Crown forests of Ontario. Specifically, the audit has not addressed questions of the form "do Ontario people like how their forests are managed?". The objective of the audit was to determine whether the plans followed sound technical protocols of preparation and, if implemented faithfully, would result in the flow of forest benefits specified in the plan. Other procedures are needed to determine if the specified flows of benefits from the various Units, in aggregate, satisfy social desires.

Finally, a caveat with respect to variability is in order. It is difficult to comprehend the immense nature of the 117 Crown forests of Ontario, and the immense nature of the technical and logistical problems associated with managing those forests. It is common to hear sweeping generalisations about the vast area of Crown forests as if each and every one of those tens of millions of hectares were identical in terms of the forest they support, the use that is made of that forest, and the manner in which the forest is managed. There is considerable commonality in the processes of forest administration across Ontario, but much less commonality in management actions, and in in the responses of the variable forests to those actions. The emphasis in this audit is therefore on the adequacy of the management process to adjust for the kind of natural variation that occurs in forests spread across 21 degrees of longtitude and 14 degrees of latitude.

ORGANISATION OF CROWN FOREST MANAGEMENT

Crown forest management in Ontario is organized around 117 Management Units. These are units of land for which management plans are prepared, and implemented. The three categories of Management Unit are: Crown Management Units on which the OMNR designs management and controls its

implementation, Forest Management Agreements on which a company prepares and executes the management plan subject to OMNR approvals, and Long Term Licences which are a transitional arrangement where the planning and implementation responsibilities are shared between a company and the OMNR. The location and type of the 117 Management Units is shown in Figure 1. There are no Units in southern Ontario because there is insufficient Crown land there upon which to base such Units.

Crown forest management planning in Ontario is in transition. Until 1986, policies and procedures for management were located in separate documents for each type of Unit. Crown Units followed the Manual of Forest Management Plan Requirements for The Province of Ontario (1977), and Forest Management Agreements followed the Forest Management Manual for the Province of Ontario (1980). Beginning in 1986, all Crown forest planning follows the Timber Management Planning Manual for Crown Lands in Ontario (1986). The new manual consolidates previous procedures, with some significant changes. The plans examined in the audit were prepared under the older manuals. The audit procedure has accounted for the changeover by reviewing plans in the context of the manual that was in force when the plans were written, and by commenting on changes in the new approach where appropriate.

The total Crown forest in the Province is of the order of 55 500 000 hectares, of which some 36 698 000 hectares (66%) is classified productive forest. The 117 Management Units account for 35 782 400 hectares (98%) of the productive Crown forest area. Some 65 Management Units accounting for 47% of the total productive Crown forest in Units have approved management plans (Table 1). A further 6 Units are operating on plans that lapsed in 1986 and which have been temporarily extended while the planning process is converted to the new system. On 22 Units accounting for 23% of the productive forest area in Units, plans are outstanding and are in various stages of preparation. The remaining 24 Units are inactive. Some of these are candidate parks, and others are Units remote from existing industry. These account for 27% of the productive Crown forest in Units (Table 1, Fig. 2).

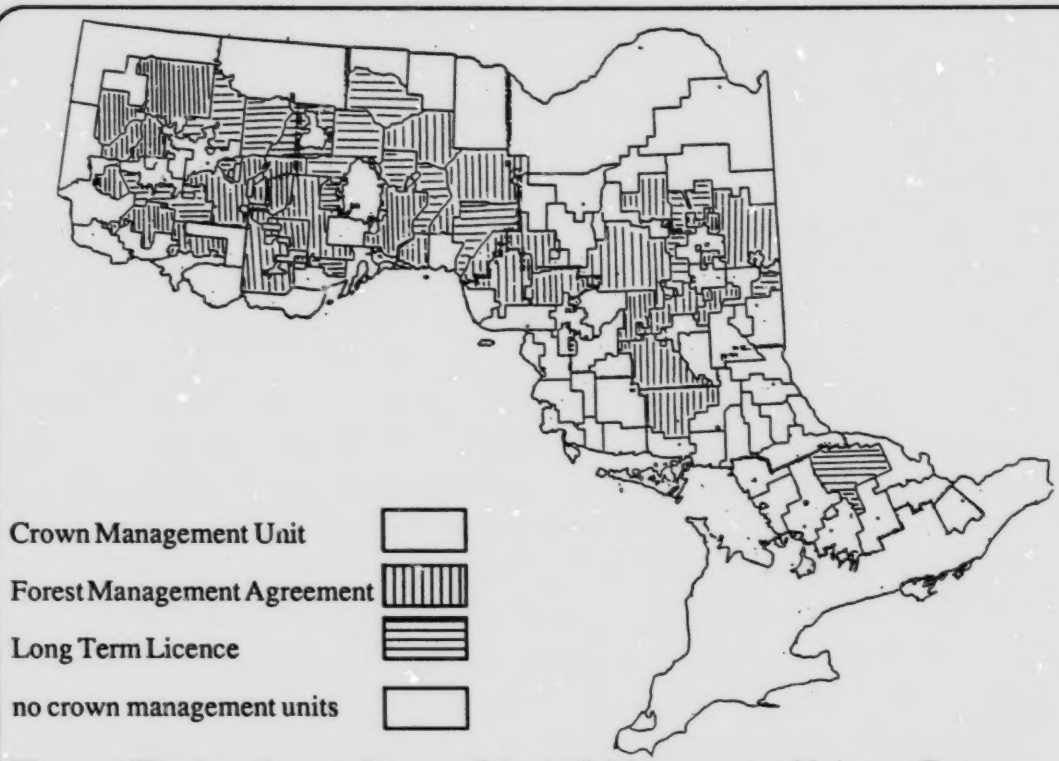

Figure 1.The location, and type, of the 117 Management Units on Crown land in Ontario.

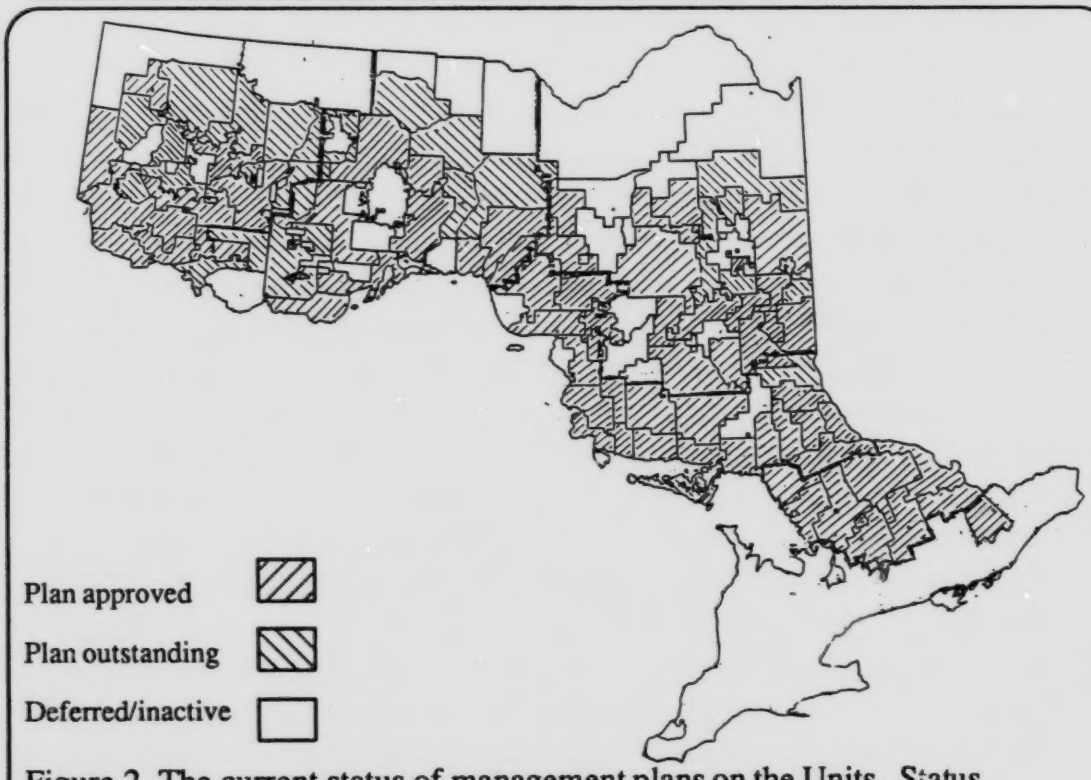

Figure 2. The current status of management plans on the Units. Status as in Table 1, with lapsed plans included with outstanding plans.

Table 1. The productive Crown forest in Management Units by type, and status of management plan. Area in hectares, number of units in brackets.

Status of plan	Management Unit Type				
	CMU[1]	FMA[2]	LTL[3]	Park[4]	Total
	(hectares and number)				
Approved	6 741 905(42)	7 631 427(18)	2 481 886(5)		16 855 218(65)
Run out[5]	934 878(6)				934 878(6)
Outstanding	1 227 937(6)	4 255 210(8)	2 934 087(8)		8 417 234(22)
Deferred[6]	1 491 001(6)		459 915(2)		1 950 916(8)
Inactive[6]	7 035 893(13)			588 269(3)	7 624 162(16)
Total	17 431 614(73)	11 886 637(26)	5 875 888(15)	588 269(3)	35 782 408(117)

1 Crown Management Unit
2 Forest Management Agreements
3 Long Term Licences to companies, including Algonquin Park
4 Federal and Provincial parks, not including Algonquin Park
5 Approved plan has expired and is not yet replaced
6 Several small Crown Management Units are candidate parks

II-TIMBER MANAGEMENT PLANNING

The objective of timber management is to control the actual development of the resource so that the resource is capable of sustaining certain levels of harvesting for industrial raw materials. For each specific Management Unit the terms of that general statement are given unique quantitative expression in a management plan. For management to be effective, the plan should; (i) contain a measurable and attainable objective, (ii) have an analysis of what features of the resource structure are preventing attainment of the objective, (iii) have a strategy for overcoming that limitation, (iv) have a program of implementation, (v) have measures of effectiveness for the implemented program, (vi) have a process of evaluating actual progress relative to the objective, and finally, (vii) establish a systematic periodic re-evaluation in which nonconformance of outcome as it is occurs in the evolving forest, in

comparison with with the objectives as stated in the plan, is corrected by changing either the objectives, the plan, the implementation, or all three.

To be realistically implementable a timber management plan must have objectives in a form that allow identifcation of what actions must be taken, at what intensity, at what time, and at what location in the whole forest. Management planning is undertaken to change the resource, and if the process plans, but does not change the resource, it is ineffective.

OBJECTIVES

The plans examined stated the main objective as management to sustain an 'industry'. None specified the level at which sustainability was sought in measurable terms, but all implied that there should be a long-term even-flow of raw material to maintain the unspecified 'industry' at least at its current unspecified level. All plans stated the attainment of a balanced age-class structure in the forest as an objective.

Statement of an objective of sustaining an industry without specifying what wood flow is necessary for that sustention makes it impossible to determine the level of management intervention effort needed to meet the objective, and makes it impossible to evaluate effectiveness of the planned management actions relative to the objective.

On FMA Units it was implied or stated that the mills to be supplied were those of the FMA holder, and that the supply was to be continuous at the level of current or planned mill capacity, but there was no target woodflow specified in the objectives. In these cases such targets only became explicit in the section of the plan dealing with surplus.

It was apparent that FMA holders had their own analyses of reasonably possible futures, and that they had specific amounts and qualities of raw material in mind when they prepared their plan. There was evidence of thoughtful approaches towards maximizing the volume return on smaller areas of forest, but since none of these analyses fit the standard planning form they are not in the plans.

The use of implied objectives poses several problems for management design. There is an explicit target structure for the forest, an implied target even-flow of wood volume, and an implied industry to sustain. Without

knowledge of the industry, and its raw material needs in both quantity and quality, it is not possible to say if the target forest structure is consistent with the target of sustaining industry. This is an important consideration because the goal of achieving a balanced age-class distribution in the forest in the shortest possible time, and the goal of an even-flow of raw materials, can be substantially inconsistent with each other in the time frame of the first rotation. In the absence of a clear statement of real preferences management design, in the cases examined, has concentrated on fast achievement of a balanced age-class distribution at the expense of maintaining an even-flow of raw materials. As will be seen, the design procedures ignore the implied even-flow objectives and deal exclusively with age-class structure. This does not appear to create difficulties on Crown Management Units where there is no formal commitment to support a specified industrial base, but it was clear on each of the FMA Units that the company desired even flow of raw materials to be maintained during the conversion to a balanced age-class structure. In these cases there was a more or less serious inconsistency within the objectives.

The objectives were largely stated independently of the available or potential markets. The objective of rapid conversion to a balanced age-class structure was applied to all working groups regardless of the availability of local markets. In the absence of local markets to consume this raw material, these objectives are hollow and unattainable before the fact.

None of the wood-flow objectives were stated in a sufficiently explicit way that they could be defaulted in any realistic sense. Therefore, all, or none, can be claimed to be met. In the broadest possible sense, the objectives of these plans are feasible in the sense that they could be obtained, although probably not simultaneously. Progress towards the objectives is not measurable except in the case of moving towards a balanced age-class structure where the use of average age provides some guidance. Key determinations in regulation (such as acceleration) are based on average age, therefore, it is the measure that is being used in design.

All plans contained objectives with respect to maintaining or increasing the non-timber uses of the forest on the Unit. The absence of response measures for the non-timber uses of the forest means that it is not possible to evaluate progress. In fact, as these objectives are stated, it would be impossible to know when they are attained, indeed they may be attained today, but no one

can tell given their ambiguous nature.

The conflict between rapid normalization of forest structure and even sustention of industry is serious, as will be shown subsequently. Rapid approach to a normal forest could substantially disrupt the flow of raw materials to industry during the first rotation (70-100 years). For at least the first 40 to 50 years of the plans examined, the harvest will come from natural stands and it is therefore crucial to consider the pattern of the harvest schedule in terms of the quantity and quality of wood that will be made available to industry from this existing forest.

In most of the cases examined the objectives were general to the extent that they could be transferred to any area of forest in Canada. The objectives were at best loosely related in any explicit sense to the Management Unit in question, to the unique characteristics of its forest, nor to the industrial and other demands placed on that particular forest.

The objectives in the plans were not chosen by comparing reasonably possible futures and selecting the future most appropppriate for the specific Management Unit. The objectives were by and large, broad statements based on generalized statements of principle from planning documents. In most cases inconsistencies amongst the objectives were known to, and appreciated by, the author of the plan, but they were included because the system desired them in the form given.

There were several plans with objectives that were not within the means of control of the manager to deliver. Examples are objectives to increase local wood using industry, or improvement of management on local private forests. Since the activities and control of the management plan for a Unit of Crown land are limited to the Crown land, such objectives are gratuitous. Put differently, would forest management on a Unit of Crown land be considered a failure 20 years hence, and the manager held accountable, if there was no additional industry at that time?, or no better management on private land? Conversely, if there was improvement in these areas what part of it would be attributable to the success of management (and the manager) on Crown land? There is no reason why objectives such as these should not appear in a Crown land plan, but there must be some reasoned connection, via actions that could be taken on the Crown land, as to how these relate to change in the world outside the Unit.

The statements of objectives in the plans examined reflect a tendency to plan for the sake of planning, rather than to plan for some specific objective with the intent of actually implementing the plan on-the-ground in order to change the temporal and spatial pattern of development in a forest to better suit the industrial and social demands on that forest.

INTEGRATION

In the format prescribed in the new manual, timber management planning has been separated from forest management planning. This was done to facilitate implementation of environmental assessment procedures, but the change is not semantic and may have weakened the management approach. Some non-timber uses are dependent on structure of the forest and flow of these non-timber uses are regulated when timber flow is regulated by altering forest structure.

Integration is handled at the local level as the plans are reviewed. On Crown Management Units the Unit Forester prepares the plan. On FMA's the plan is prepared by a company forester, with the Unit Forester acting as a link to the OMNR planning system. In both cases, the draft plan is reviewed by a group from the Ministry representing the various timber and non-timber values. This team discusses the interaction of timber management activities, and the long-term outcome of those activities, with the other uses, and determine the constraints to be placed on timber management. There was no evidence of the use of measurable cause-effect relationships in this process. In this respect the quality of the plan is directly proportional to the level of interaction achieved in this process. In four of the six cases there was good involvement, particularly between the on-the-ground timber and wildlife people. In those cases it appeared to the auditor that integration as it appeared in the plan was the best achievable in a situation where most of the key relationships are not known except in a most general form, ie., in a situation where rigorous optimization cannot be applied. The manner in which these plans gave explicit local form to vague planning principles (eg., diversity) was arrived at with full understanding on the part of the timber and wildlife people for the concerns of each other.

The problem with integration at the Unit level is that the basis for the plan, as it is actually laid down on maps and will occur in the forest, is not known in any easily cummunicable form except as a set of constraints. For example, the two people who put the harvesting-habitat element of a plan together

reach site-specific, and time-specific, decisions with respect to management interventions such as where and when to harvest. This is achieved through their understanding of the particular forest with its particular structure and use pattern. The algorithm of design is experience in the local forest, and is not quantifiable. If those involved have sufficient experience, decisions reached in this manner can have a reasonable probability of resulting in 'right' local responses in the forest when they are applied. However, because these are independent, site-specific decisions they will not be optimal in any rigorous sense for the Unit nor for the Province. Further, they may deviate from guidelines because of local conditions, and can appear 'wrong' to the remote person who judges only in terms of conformance with planning guidelines. There is considerable risk in this situation that a rather good plan in the forest could be faulted on very general principles in a hearing remote from the forest, a situation both lamentable and devastating to the intellect of the timber and wildlife people who conceived the plan. In four of the cases examined the wildlife and timber people believed that recent harvesting had increased the diversity of stand structures in the forest, and that the habitat was improved. In one case the wildlife person spoke enthusiastically of "using the company to do our job of breaking up the natural monoculture", and was clearly proud of what had been achieved. It is unfortunate that there is no objective measure of this real achievement.

The fundamental problem with the integration of non-timber values in the cases examined is that they are not being managed towards any measurable objective level. The non-timber values entered the management planning process as constraints to timber management design, and not as part of an objective for forest management design. Some non-timber elements of the plans examined were superficially treated and barely believable. They were not optimal, and there was an absence of quantitative rigour. In some cases they appeared to reflect careful judgements, while in others they were simply a mechanical application of a set of constraining rules.

AREA REGULATION

The principle of area regulation is that an equal area is harvested each year so that over the period of one rotation there will be an equal area in each age-class from one year old to the age of rotation. To achieve this, the area of productive forest is established, the age of rotation for the tree species is established, and the annual area for harvest is determined by dividing the area of productive forest by the rotation age. In the OMNR case this is done

separately for each species working group.

The universal difficulty with an area approach to regulation is that the product of a forest is not area, but rather raw material or habitat, and these have quantity and quality measures that are not captured in a measure of area. The real issue in timber management is the availability of an appropriate volume of raw material of appropriate quality, and not the availability of a "correct" number of hectares for harvest. The Timber Management Planning Manual (1986) states on page1;

> "The objective of the forest management program on Crown land in Ontario is to provide for an optimum continuous contribution to the economy by the forest-based industries consistent with sound environmental practices and to provide for other uses of the forest. The purpose of timber management planning is to organize the activities of harvest, renewal, and maintenance on the forest to ensure the availability of forest products from an area consistent with this objective".

Thus, regulation of the forest is based on availability of area, while the objectives of management are based on availability of volume. This is true of all management activities. For example, it is not the area planted that is of interest in the management sense, but rather the volume of raw materials that will ultimately be available from that area as a result of the planting. Area is used to regulate, but area is not the thing that is being managed. The same is true of habitat in the sense that wildlife populations do not need just forest area, but forest area with particular characteristics of vegetation pattern and stages of development.

The link between area of harvest, and volume recovered by harvesting that area, is crucial to the successful design and implementation of forest management. For example, the first objective in the management plans examined was stated as a volume objective, the harvesting rights to District Cutting Licences are assigned on volume, and the contemporary demand for wood volume determines each year how much area will actually be harvested. Ultimately, the success or failure of timber management will be judged by the degree to which it provides a continuous flow of raw materials to industry, and not on the availability of hectares for harvest. Clearly what is on those hectares is crucial.

In the OMNR, this link between area of harvest and volume of harvest needs

substantial improvement. The key is to use area to achieve regulation, while realizing that it is the flow of raw material that is being managed, and not the flow of hectares. Much of the correspondence associated with the approval of management plans stated, or implied, that it was actually the flow of hectares that was being managed. Inconsistency in viewing area regulation as a means to the end of regulating raw material flow is causing confusion between industry and the OMNR.

There are two problems that need attention. First, area regulation strictly applied will always result in an unveven flow of raw materials in the transition from a wild unbalanced age-class forest, to a forest with a balanced age-class structure. When conversion is complete at the end of the first rotation, the flow of raw materials becomes precisely the same each year because stands of precisely the same age and timber characteristics are harvested each year. However, in the intervening years, area regulation assigns a hectare for cutting independently of the timber characteristics of the stand that is on the hectare, with the result that the flow of wood volume varies from year to year depending on the stage of development of the stands on the areas assigned for harvest. For example on the six units examined, the flow of raw materials from the forest declines over the transition period for most working groups.

The second problem is that markets, not management plans, determine how much is actually harvested in any one year. A stand is not harvested simply because the management plan says so, but only when both the management plan permits its harvest, and markets require its harvest. The variability of markets from year to year is a problem not only for rational economic development, but also a problem to the introduction of forest management. It is axiomatic that if a raw material cannot be marketed, it cannot be managed.

Volume regulation could greatly reduce the problems with respect to even flow and market variations, but would bring insurmountable problems in terms of dealing with the myriad reductions to the land base to protect non-timber values. While no form of regulation is without its problems in a specific case, the use of area regulation in the Ontario Crown forests is entirely appropriate as a means of determining maximum allowable depletion. Given the form and nature of the substantial constraints imposed on the production base for timber management by non-timber values, an area

approach is more reasonable than use of volume regulation.

The application of area regulation by the OMNR is appropriate to the situation and soundly applied. Subsequent sections of this report will demonstrate, however, that there is insufficient link from area regulation to measures of forest product, particularly volume. The absence of this area-volume connection is damaging to the evaluation of objectives at all levels of planning in the OMNR.

DETERMINATION OF AREA and ROTATION

In area regulation, any actions that decrease rotation age, or that increase the area base, have the effect of increasing the allowable annual depletion. The reverse is also true. The credibility of an area approach to regulation largely depends on how the area base, and the rotation age, are set.

In the OMNR, additions to, and depletions from, the land base are recorded in the management plan at each revision. Because the forest is highly fragmented in both its biological and geographical structure, adjacent stands may not be characterized as in the same category of the land base for management, or one may not be in the production land base at all. This makes the bookkeeping awkward and somewhat complex. The accounting of the land base as it is presently applied to Crown land is summarised in Figure 3. Each block of the diagram contains a separate record for each working group, and similarly each working group is separately tracked in the 'flow' among blocks. The basic division is between protection forest, which is not eligible for harvest, and production forest which is eligible for harvest. The stands that make up both protection forest and production forest are identified on maps. Due, for example, to a stream-side reserve part of a stand may be in the protection forest and part in the production forest. Hence the map base takes on major importance as the fundamental record.

A portion of the production forest is made up of stands that require treatment as a result of harvesting conducted prior to the introduction of management planning, and these do not form part of the base for calculating the allowable annual depletion. The maximum allowable depletion (MAD) base consists of those stands in the production forest that are currrently defined as free-to-grow. These stands comprise the area base used to calculate the allowable annual harvest in area regulation. Stands managed under selection or partial cut silvicultural systems remain in the MAD base. Stands which are

harvested in conventional operations are depleted from the MAD base, as are stands that are harvested by natural causes such as wildfire, insects, and disease. Stands, or parts of stands, that were scheduled for harvest but which were by-passed in the logging operation remain in the MAD base (Fig. 3).

Depending on the working group, and the particular Unit, some depleted areas are left to regenerate naturally, and some areas are treated. All depletions from the MAD base, and all stands in the initial production forest that are not free-to-grow, are assessed for stocking, normally in the fifth year after harvest or treatment. Those that are satisfactorily stocked are then assessed for free-to-grow status. Stands that pass both the stocking and free-to-grow assessments are returned to the MAD base, and those that do not qualify remain out of the base until natural development over time, or the results of treatment, qualify them for entry.

The bookkeeping for this area system is already in place. Spot checks of individual stands in the Units examined found that they were properly classified. A previous form of re-entry of cutover to the MAD base by means of FRI determination had weaknesses, but that procedure no longer applies.

One potential problem with the MAD base control lies in the handling of reserves. When an area is formally declared part of the protection forest, it is removed from the MAD base, and no longer contributes to the allowable annual depletion calculation. On the other hand, substantial areas are designated as areas of concern where harvesting can occur, but under special control. Since wood from these reserve areas can be expensive, because of the special constraints on harvesting, there is a tendency for harvesting to by pass them unless the sites support particularly good quality timber. When these areas are not harvested they remain in the MAD base. If reserve area that is allocated, but not harvested, accumulates to an appreciable size it will have the same effect as inflating the land base. In this circumstance 'reserve' areas that in all likelihood will not be cut remain in the MAD base and contribute to the size of the allowable harvest area. Since the harvest actually taken comes from outside these areas, this necessarily means that the the latter area is over-harvested. The retention of reserves in the MAD base when there is no intention to harvest these areas has the effect of concentrating the harvest on a smaller area. Areas that will not be harvested for whatever reason should not be in the MAD base.

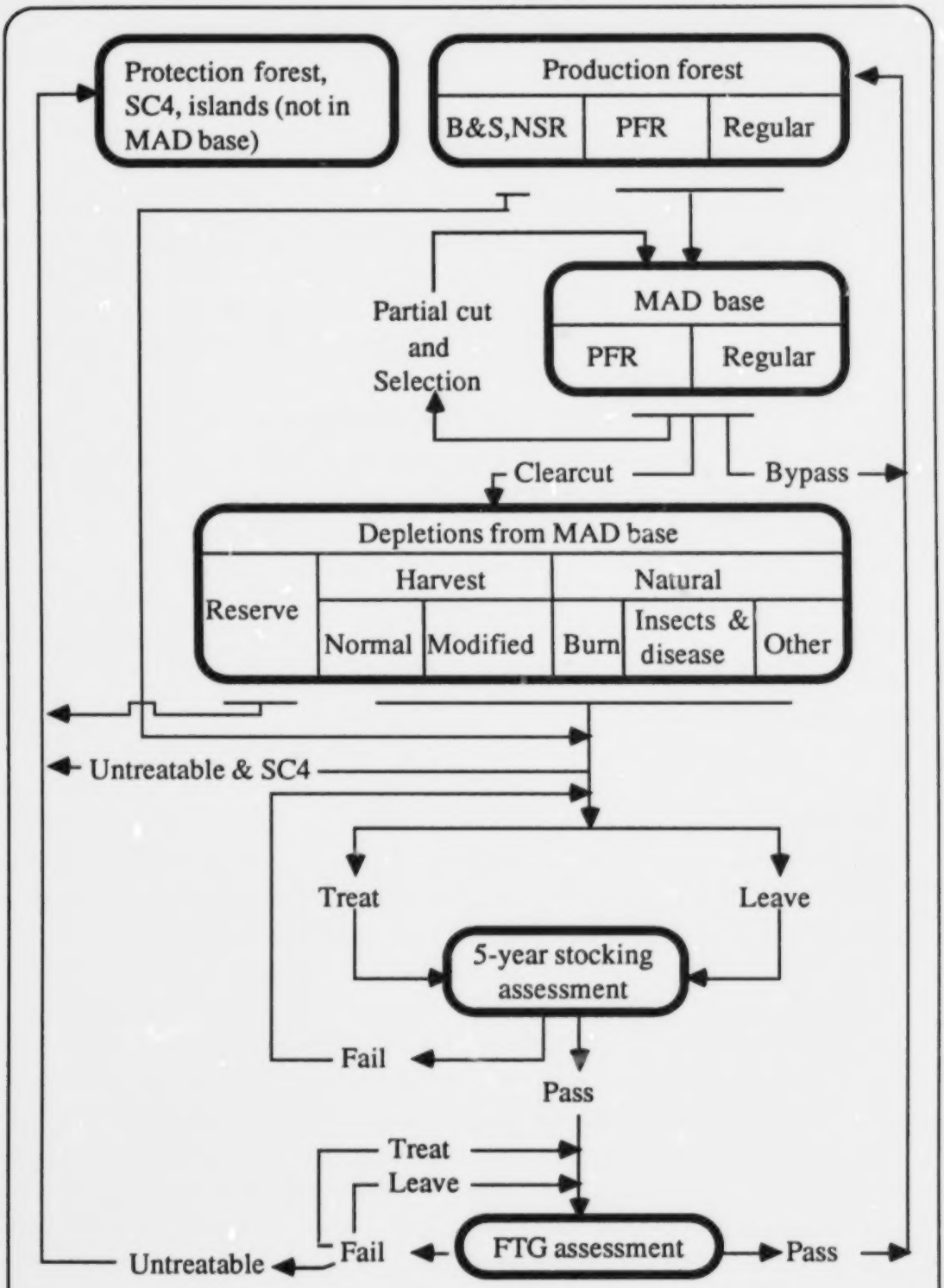

Figure 3. A summary of control on the area in the maximum allowable depletion base. See text for explanation.

Similarly there was evidence of 'unofficial' reserves. For example, in response to a question about the timing of the second cut on one area designated for two-cut harvesting because of its location, the answer was "never". When the first cut is made the area is depleted so that it does not contribute to the MAD base in the sense described above. However, not taking the second cut does reduce the volume flow, and does influence when the area will return to the MAD base. If this unofficial protection forest finds its way back into the MAD base, by virtue of its stocking as a residual mature stand, the problem of concentrating the harvest on a land base smaller than that used in the MAD base will be exacerbated.

The magnitude of these issues is large. In one instance, a plan showed withdrawal for other uses equivalent to 6% of the allowable annual depletion area, a 4% loss to natural harvesting, and a 6% mandatory no-cut designation. All of this is separate and distinct from depletion by harvesting. The withdrawals were removed from the land base as they actually occurred, as were the natural harvests, but there were potential problems with the bookkeeping of the no-cut areas, particularly where the restriction appeared to be temporary. To the extent that area is allocated for harvest, but not depleted, it can artificially increase the harvest pressure on the remaining land base.

The removal of a cutover from the MAD base reduces the allowable depletion for subsequent periods until that area again supports stands that are free-to-grow. This motivates rapid regeneration since the faster the area is returned to free-to-grow status, the higher is the allowable annual depletion. This motivator may not work effectively in situations where the land base is not under real harvesting pressure. Thus, when there is land available for harvest surplus to current market demands, there is no motivation to ensure rapid return to free-to-grow status, and the cutover areas may not be handled in the manner most appropriate to long-term considerations. It may not be 'bad' to reduce regeneration efforts in these cases, but it is dangerous to do so without review. Reduced efforts to place cutover back in the free-to-grow status will result in a reduction of the allowable harvest level over time. That may be acceptable in the context of contemporary markets, but may be creating real problems for the future if markets improve and there is a desire to harvest at higher levels.

Ideally the rotation age is that period of time which produces a stand of

economic volume with trees of economic size. Thus, determination of rotation implies that the products to be harvested are known or forecast and, in area regulation, certainly determines the timber characteristics of the stands that will be available for harvest at the end of the first rotation. Rotations on the FMA's examined were related to raw material needs of the mills owned by the FMA holders. Rotations on the Crown Management Units were set in the context of the silvicultural guidelines for the various working groups, and the needs of local processing plants served by the Unit. For the most part, all the rotations were set at, or very close to, those specified in the appropriate guideline.

There is potential to increase the allowable annual depletion level by the artifice of setting a shorter rotation age. This has the effect of yielding an immediate increase in the allowable depletion. If the reduced rotation is not consistent with the way the stands actually develop in the forest, the resultant problem does not become a reality until those stands are scheduled for harvest in R years time. At that point, the appropriate area will be available for harvest, but the volume supported on the area will not be economic and/or the tree sizes will not be economic. The current system requires justification of all changes in rotation length away from the standards. However, there is nothing in place to evaluate the reasonableness of the currently accepted rotations in terms of their consistency with stands of economic volume in trees of economic sizes for a specified industrial base.

Current regulation procedures employ a method of calculating allowable depletion known as acceleration. The principle of acceleration is that when the average age of all the stands of a working group in the forest exceeds one-half the rotation age, the allowable depletion is increased in proportion to the difference. This increased rate of harvest of area is supposed to speed up the approach to a normal forest structure. In fact, it can have the effect of destabilizing the approach somewhat, depending on the initial age structure, but in any event it simply is not possible to reach the normal balanced age-class structure in less than R years. Acceleration gives the illusion of a more rapid approach because it 'moves' overmature age classes to the regenerating stage. In fact, it creates more area of young stands than should be created, with the result that the age-class that becomes eligble for harvest in R years will have too much area in it, leading to further acceleration. The rationale for use of accelerated harvesting in the OMNR is not clear.

The use of acceleration increases current harvest levels both in area depleted, and in volume generated by that area depletion. Because acceleration is intentional short-term over-harvesting, it also means that there must be a decrease in both the area depleted, and the volume generated by that depletion, over time. This is a principle cause of a decline in harvest volume over time forecast for the Units examined. It is not clear why acceleration is mandated in the OMNR when it is clear there are insufficient markets to absorb the volume generated by harvesting the additional area. Particularly, it seems unwise to accelerate current harvest in working groups, and on sites, where there is an opportunity to store wood on the stump in order to even out the future wood flow, and to smooth out wood flow with respect to markets during the transition to a balanced age-class structure. The use of acceleration is creating additional surpluses in a situation where surplus is already a serious impediment to orderly management. Acceleration as mandated in current planning is not based on sound biological and economic principles. The use of acceleration should not be mandatory, but should be available as a regulation tool when forecasts of the changing age-class structure over time indicate it is a safe and appropriate way to take advantage of a contemporary market.

ALLOCATION

Once the allowable annual depletion has been determined, the actual stands to be depleted in the harvest period are identified on maps. Eligibility for depletion is determined on the basis of the oldest stands in a working group being harvested first. Current rules require the allocation of 100% of the allowable depletion area. Thus, the oldest stands in a working group must be identified on maps up to the total area of allowable depletion whether or not there is reasonable prospect of harvesting all this area. In the cases examined, actual depletion area was generally short of the allowable depletion area as a result of insufficient market for the wood generated by harvesting the full area, and as a result of removal of areas of concern after the allocation. In these circumstances the allocation of 100% of the allowable depletion gives a false impression of progress towards a managed forest. The plans show 100% allocation and thus show an apparently significant step towards altering the age-class structure in accordance with the objective. However, there is no possibility of making all the harvest, and hence the realistically achievable progress towards a balanced age-class structure is substantially less than indicated in a management plan.

In a similar vein, the plans allocate species mixes that are not marketable and hence will not be cut, again hiding the true position of progress towards a managed structure. A further issue here is the allocation of areas of forest that are not harvestable either by reason of site or inoperability. Although this is a matter of what should be in the MAD base, such an allocation is not a realistic reflection of what will actually be done in the forest. Allocation of area that will not be harvested leaves the plans as somewhat theoretical notions, rather than working documents used to guide actual change in the forest.

The only apparent reason for allocating 100% of the allowable area, as opposed to showing what is reasonably practical to achieve, is the calculation of surplus. The plans would be more credible guides to management if they allocated realistically, and calculated the surplus separately.

The principle behind an oldest-first rule in allocation is not clear, particularly as it is applied in practice. Oldest-first is another way in which the flow of wood volume generated by the harvest of a constant area is made to vary over time, a feature it would be wise to avoid in area regulation. Figure 4 shows three stylized yield curves equivalent in form to those employed in the OMNR planning system. The figure shows the stands on each site initially increasing in volume with age, but eventually decreasing in volume when they reach overmaturity and begin to break up. Maximum volume reached is greatest on the best site, and the age at which break up commences is earliest on the best site. While the latter may not fit some conventional wisdoms (even textbooks) it is realistic, it reflects the understanding of stand dynamics of the foresters on the Units examined, and it reflects the actual yield curves used in the OMNR.

Limiting the discussion of oldest first to site class 1 in Figure 4, it is clear that if the rotation age is 60 years, and the oldest stands in the forest are 80 years, then harvesting the oldest stands first will result in a decrease over time in the volume recovered from the constant annual area as successively younger stands are cut until stands of rotation age are being harvested. On the other hand, if the rotation is 60 and the oldest stands are 100 years, then harvesting the oldest first will result in an initial increase in the volume recovered from the constant annual area, until stands of age 80 are being harvested. Beyond this point, the volume recovery from the constant annual area will also decrease. The cases examined included working groups in both of these situations.

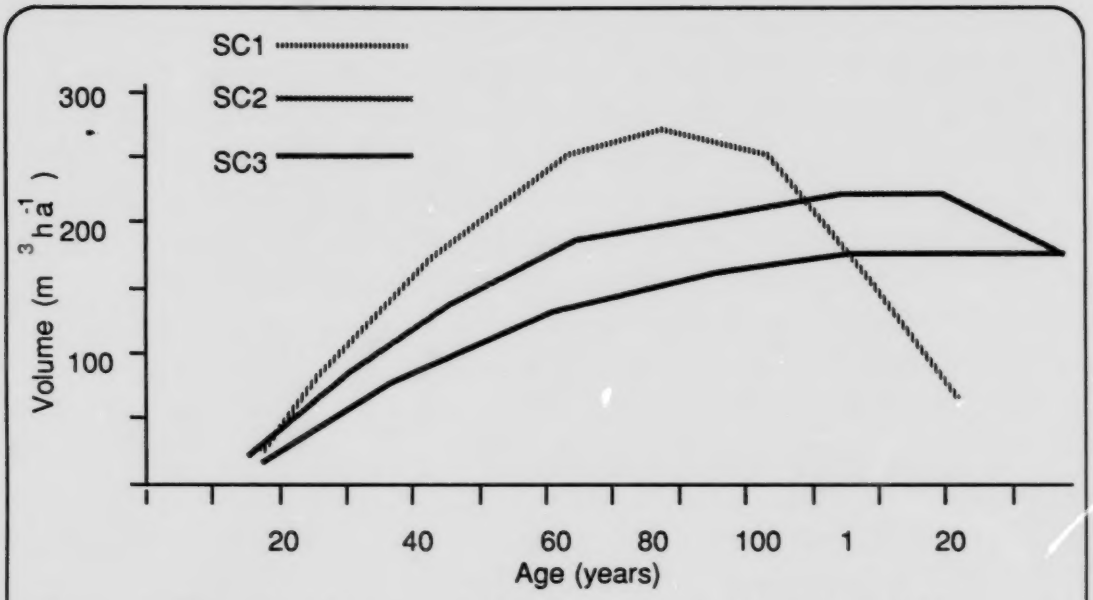

Figure 4. Stylized yield curves for three site classes of a single working group. See text for discussion.

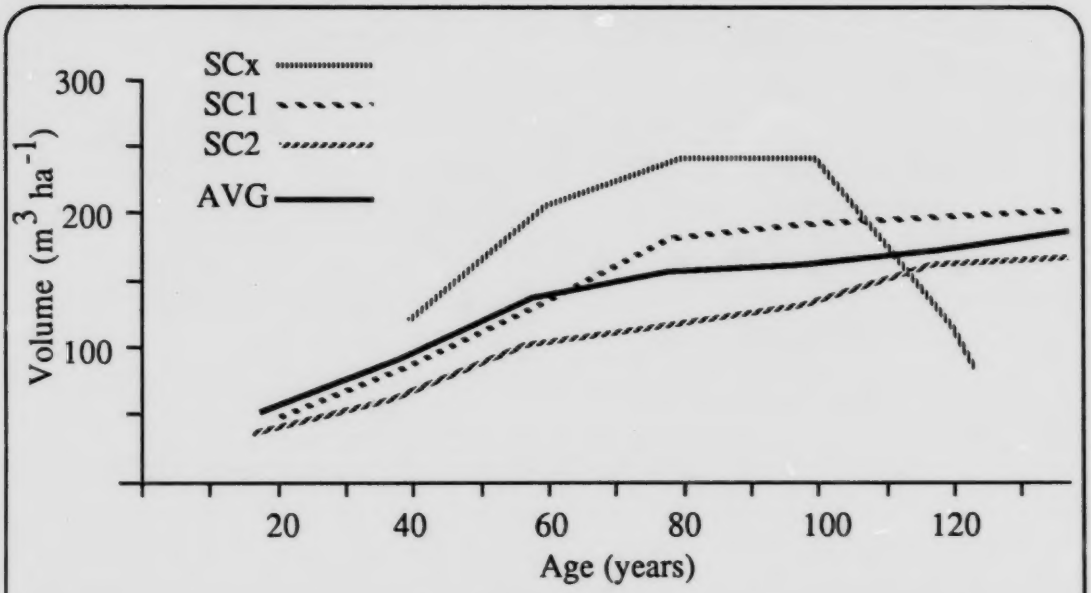

Figure 5. Actual yield curves for the spruce working group on one Unit as determined from the FRI data base and as used in forecasts. See text.

From the point of view of regulation it is important to determine what purpose is being pursued by application of the oldest-first rule. If the goal is to capture the maximum amount of volume in the stands harvested, then oldest-first is essential in situations where there is complete utilization of the allocated area. In this case, the rule is to cut the oldest stand in terms of developmental stage and not in terms of chronological age. However, in situations where there is incomplete utilization of the allocated area, the oldest-first rule is roughly equivalent to eating only spoiled apples from a barrel. This can be particularly devastating if the apples are eaten so slowly as not to keep pace with the rate at which they become rotten.

In the cases examined, the oldest-first rule was followed because it was 'the rule'. This resulted in some unusual decisions. For example, Figure 5 shows actual yield curves for one working group on one of the Units examined. In this case, while the differences in site response were known, an average curve was used to determine the oldest-first allocation. The result was that 140-year-old stands of site class 2 were being harvested while 100-year-old stands on site class X were breaking up. The effect was to allow stands on the best sites to decline rather than to capture the opportunity to harvest them at maximum volume and promptly return these best sites to production. Oldest-first only makes sense in terms of stage of stand development. The correspondence file in this case bore a letter directing the Unit Forester to allocate the chronologically oldest stands first because that was the way it was supposed to be done. This showed a fine grasp of the niceties of administration, but not much comprehension of stand and forest dynamics.

There is a need to recognize that what counts in yield is not chronological age as determined from FRI, but the stage of development or physiological age of the stand. The use of oldest-first should be a principle, but not a hard rule. Particularly, it is essential on Units with a mixed harvest of pulp and sawlog material, to allow interpretation of the oldest-first harvest rule in allocation to account for the different needs in these products.

There is a logistical problem with the approval of allocation that has the potential to severely disrupt forest operations. Allocation of stands for harvesting is made for the 5-year period of the plan on the presumption that stands for the 'sixth' year will be designated in the new plan prepared at the end of the 5-year cycle. It is unrealistic to imagine that the process currently in place for plan approval can deliver an approved allocation in time for

orderly planning of harvest operations in the 'sixth' year. Design and construction of roads must have a lead time of at least one-year, considerably more than the process seems to allow. Some adjustment to the procedures which maintains the credibility of the 'protective' aspects of approval, but allows timely development of the harvest operation, is needed.

INCOMPLETE CUTOVER

The most striking feature of forests, at least to those who work in them, is the fact that they are not uniform. It is unreasonable to think of a forest in average terms as if it were the same over its entire extent. It is equally unreasonable to expect the same response to a silvicultural intervention across an area of hundreds of thousands of hectares. Nowhere is this more true than with the act of harvesting. The cutter who is payed by the unit volume he produces sees the variability in the forest as extreme, and as a problem to him in terms of maintaining constant productivity, and therefore constant wages. Variability is a fact in the forest, and the type maps of FRI capture only that variability which is visible at the scale used, and in the variables assessed, by that survey.

The harvest of an allocated area rarely results in a completely uniform post-cut condition because of variability in the stand. Portions of a stand may not be harvested because species are unmerchantable, size of the trees locally make the stand inoperable in an economic sense, site locally is such that it is inoperable in an economic sense, or because the site locally is such that it would not be possible to regenerate if it were harvested. These are realities in the variable forest. When these conditions occur at a scale that is mappable, they are generally not allocated for harvest because they are excluded from the MAD base. However, when they occur in local pockets within allocated stands, they result in patches that are by-passed in the logging operation.

Because areas of by-pass can reach significant proportions, especially on small Units, it is necesasary to deal with these situations in terms that maintain the credibility of the MAD base for the determination of allowable depletion. When a non-merchantable species that was scattered through the original stand is left standing, it maintains a dispersed cover over more or less the entire original stand area. If this cover constitutes less than 0.4 stocking, the entire area is depleted and stays in the original working group. In this case, subsequent silviculture must deal with the residual stand of non

working group species, if only to prevent stand development from leading to the establishment of a different (non-merchantable) working group.

Where the scattered residual stand constitutes more than 0.4 stocking, the area is listed as a depletion from the original working group, but is re-assigned to the MAD base of a working group appropriate to the species mix of the post-cut residual stand. The principle here is reasonable, but its application is not straightforward, and it has the effect of decreasing the area of a merchantable working group while increasing the area of a non-merchantable working group, hardly a sound management practice in an economic sense.

Where the residual stand is concentrated in patches such as result from variations in operability due to stand and site conditions, or from small patches of unmerchantable species, a different rule applies. In these cases, if the by-pass area exceeds 8 hectares it remains in the MAD base for the working group of the original stand. This can be a significant misrepresentation if the patch results from leaving a clump of an unmerchantable species, since it results in an unrealistic inflation of the MAD base for the original (merchantable) working group.

If a by-pass patch is less than 8 hectares it is ignored, and the entire area of the stand is depleted from the MAD base for the working group. Among other things, this results in inconsistencies between depletion area and treatment area reported in subsequent silvicultural activities. It also means that a portion of the MAD base for the working group is not in fact valid. Although this should be an insignificant area in most cases, it could lead to significant errors on small Units, and there is no procedure in place to check the accumulation over time of area in this condition.

An interesting feature of the by-pass issue is that wildlife planners like to see by-pass, indeed much of their design efforts are towards the creation of precisely that sort of patchiness. The administrative concern aimed at eliminating by-pass that was seen in some cases could therefore be counter-productive. Discussion of by-pass and how to handle it seems to have occurred independently of the views of the on-the-ground wildlife people, and they should be involved in these discussions. It may be that by-pass is a 'good' thing that bears justification, in whole or in part, on grounds of wildlife habitat management.

There is no straightforward solution to the by-pass issue that does not result in inaccurate representation of the forest estate, but consideration of better ways to handle these situations is needed. The thrust of the current approach to handling by-pass is to maintain an accurate record of what is actually out in the forest to the extent possible, given the scale involved. However, confusion with respect to this issue was encountered in the Units examined, the degree depending on the complexity of the forest involved. Review of the 8 hectare limit is in order since that appears to have been set on the basis of what the FRI could map, rather than on grounds of reasonableness with respect to regulation on any particular Unit. To the extent logistically possible, areas of unmerchantable species should be removed from the MAD base of the original stand and placed in an appropriate working group. Where the stand is inoperable due to tree size characteristics, the area should be left in the MAD base if there is reasonable probability that the trees will reach usable size while there is still a realistic opportunity for harvest operations to capture them. Otherwise the area should be removed from the MAD base and placed in the protection forest. Where the by-pass results from site conditions, the area should be removed from the MAD base and placed in the protection forest. The limiting feature in all of this must be logistical reality, and that means there is a need for local flexibility to reflect local reality.

SURPLUS

Allocated harvest area surplus to the needs of an FMA holder or Long Term Licence holder is calculated. There is no calculation of surplus on Crown Management Units. The principle of the surplus calculation is that a company must match its industrial needs to the available harvest area, rationalize any differences, or declare as surplus that area which will not realistically be harvested in the management period. The Crown can then licence a declared surplus to another company. The surplus, and any re-assignment of it by the Crown, are determined on the same 5-year periodic basis as the management plan. Surplus is declared in terms of working group area and may be in the form of the working groups used by the company, or it may be in working groups unmerchantable in the processing plants operated by the FMA or Licence holder. The objective is to identify raw material opportunities, and needs for new markets .

Surplus is determined by working group area which is awkward for both the FMA or Licence holder, and for any planner looking for new markets. To

discover industrial opportunity, or to search for new markets, the amount of wood available must be known and not just an amount of area for a working group that supports an unknown volume of wood in a mixture of species. Surplus is determined for the current planning period (five years) and out of context of a long-term view of wood supply. The absence of a realistic connection between area and volume renders this a sensitive issue. Area regulation absolutely assures hectares available for harvest over time into the future. However, it is apparent from the previous discussion that the same number of hectares harvested annually will not yield the same volume of wood annually during the transition to a normal forest. Although it is obvious that industrial mills operate on volume rather than on hectares, there is substantial disagreement as to whether current surplus area constitutes a volume surplus to maintaining the capacity of dependent processing plants.

To resolve this issue there is need for a rigorous connection of a volume forecast to an area forecast developed from a realistic application of the allowable annual area depletion calculation. No amount of work with area alone will help, because area is not the problem. There must be a forecast of the flow of raw material volume associated with the area to be harvested over the planning period that permits examination of future increases, or reductions, in volume availability, and of the opportunities to balance any current surplus against any forecast reductions. This does not in any way reduce the primacy of area control. It merely emphasizes that in the objectives of timber management plans, and in the reality of the industrial world, continuity of volume flow is the essential measure of management effectiveness. Therefore, the volume related to the allowable harvest must be forecast well into the future if there is to be realistic appraisal of a modification to a plan such as is intrinsic to reassignment of surplus hectares.

It seems strange that surplus is not calulated for Crown Management Units. In the cases examined there were obvious surpluses (ie., under-cutting) on the Units for at least some working groups, yet these are not recorded in any systematic manner that would permit examination in aggregate form. This is an awkward situation because there is no formal dedication of the flow of wood from a Crown Management Unit to specific processing plants, even though there are clear historical patterns of supply that are being maintained. Hence the determination of surplus on these Units will require clarification of this matter.

In the current situation the surpluses are artificially inflated by accelerated harvest calculations, and there is no check to see if current consumption of an area surplus is contributing to a future volume deficit. In one case examined, acceleration did exactly that. This unnecessarily increases the uncertainty in industrial planning. The current approach to this issue appears to engender rationalizations of surplus, rather than analysis of the situation with a view to maximizing long-term returns from the flow of raw material volume. Clearly there is a need to curb hoarding of land if new industry is to be encouraged, but this must be achieved without cutting off opportunities to smooth volume flow over time as area regulation takes full effect.

To examine surplus in a realistic manner, it must be possible to explore the nature of the surplus in terms of product quality and not just establish its existence in terms of hectares. For example, while it is clear that area surpluses exist at present, it is not clear to what extent these surplus hectares support stands containing material suitable for sawlog production. Since sawmills offer a more flexible alternative to the redistribution of surpluses than more capital-intensive processing plants, and since the higher value of sawlogs can support longer transporting distances than lower value raw material, an industrial development opportunity could be hidden.

FORECASTS

> "It has been said that the greatest dilemma of mankind is that all knowledge is about past events and all decisions about the future. The object of this planning, long-term and imperfect as it may be, is to make reasonably sure that, in the future, we may end up approximately right instead of exactly wrong".
>
> (from Forest Production Policy Options,1972)

Decisions are choices among forecasts about the future, thus the quality of forest management hinges largely on the accuracy of forecasts used in its design. In the OMNR system the area forecasts are explicit and open to examination. Although there are no explicit volume forecasts, except on FMA's, a volume forecast is implicit in the manner in which management plan objectives are stated, and in the choice of management interventions. It is implied that harvesting a constant area every year, will make a consistent flow of volume available to industry. While the area forecasts are exact there is much ambiguity with respect to the volume that will be available from harvesting the exactly forecast area.

The issue here is the realism of the forecasts. Do they provide a realistic prognosis with respect to future availability of wood? To be realistic, forecasts must be based on reasonable representations of the operative dynamics in the world they attempt to forecast. The area forecasts used by the OMNR presume that the oldest stands are always cut first, and that the full allocation is harvested every year. This is true of calculations made in both the old format and of the calculations of OWOSFOP. Indeed OWOSFOP is a faithful replica of the 'hand' calculations. To the extent that harvesting on a Unit does not actually follow oldest-first, and does not actually extend to removal of the full allocation, the forecasts of area are inaccurate (no matter how exact) and they depict a future forest development pattern that will not occur. These assumptions are unequivocally defaulted in the cases examined. For example, a subsequent section of this report will show that there is extreme variability in the proportion of allowable area actually harvested across the Units, with only an average of about one-half of the allowable area harvested annually at present. Similarly, if stand growth over time is not consistent with the yield curves used for various working groups, forecasts of wood volume availability are defaulted on two counts; inaccurate area forecasts, and inaccurate yield curves relating area to volume.

The forecasts of area available for harvest are precisely exact, but inaccurate. The faulty presumption that all the allocated area will be harvested means that the accuracy of the amount of area available (fixed at 1/R of the MAD base) does not extend to any degree of accuracy in terms of the area that will actually be harvested, nor, therefore, to which age classes will be harvested. Consequently, the forecast patterns of age-class structure in the plans are inaccurate. The approach to normality shown in the plans will not be achieved in the forest. Without reasonable representation of the age classes harvested, volume forecasts cannot be reliable. In short, the only forecast that is reliable in this system is the trivial one that 1/R hectares will be made available for harvest (although not necessarily harvested) each and every year into the future.

In these circumstances it is difficult to evaluate the management plans in terms of the degree to which they address the principle objective, namely the provision of a continuous supply of raw material to industry, or the secondary objective of moving the forest towards a balanced age-class structure. These issues have not been addressed in a realistic manner in the planning process.

The capability to make reasonable forecasts is easily within the powers of the OMNR. The Ministry has most of the tools in place, but has chosen not to use them apparently in the mistaken belief that to do so would somehow imperil the purity of area regulation. The issue here is not area regulation, but merely how to forecast realistically the area and volume availability that will result by following a given pattern of area regulation on a specific Management Unit.

Under the circumstances it is possible to claim either that future availability of raw materials will, or will not, meet the desired levels with respect to volume, economic harvestability, sawlog availability, or indeed availability of any specific wildlife habitat. The area forecasts in the plans are for a situation that is not the way the future is unfolding, and since all other measures must be assessed through their linkage to area, they are (where present) inaccurate. In the sense of the quote from the 1972 Forest Production Policy Options area forecasts used in the OMNR planning are "exactly wrong". In fact, the approach to planning appears not to have been concerned with attempting to face the reality of the unfolding future, but only with the existence of a current plan. The most important point here is that there is no warning system in place to detect failure to converge on either the volume, or normality, objectives in advance of an actual failure. This does not allow lead time to design and implement corrective action.

The present system has no credible forecast of forest development without, or with, management intervention. It is therefore not possible to evaluate the proposed management actions with respect to 'fixing' the management problem, which is itself undefined.

YIELD TABLES

Allowable annual depletion is determined by area, processing plants consume volume, and the link between these lies in the use of yield tables. Yield tables used in management planning in the OMNR are empirically derived from the normal yield tables of Plonski (1981). For each Management Unit, volume of each stand is estimated by entering the normal tables with the working group, age, and stocking attributed to the stand by the FRI. These empirically determined stand volumes are averaged for each age class, and in some cases plotted over age as a curve (Figure 6). The yield curves in Figure 5 were determined in precisely this fashion. If site classes are not separated into forest units within the working group, one average yield curve is used

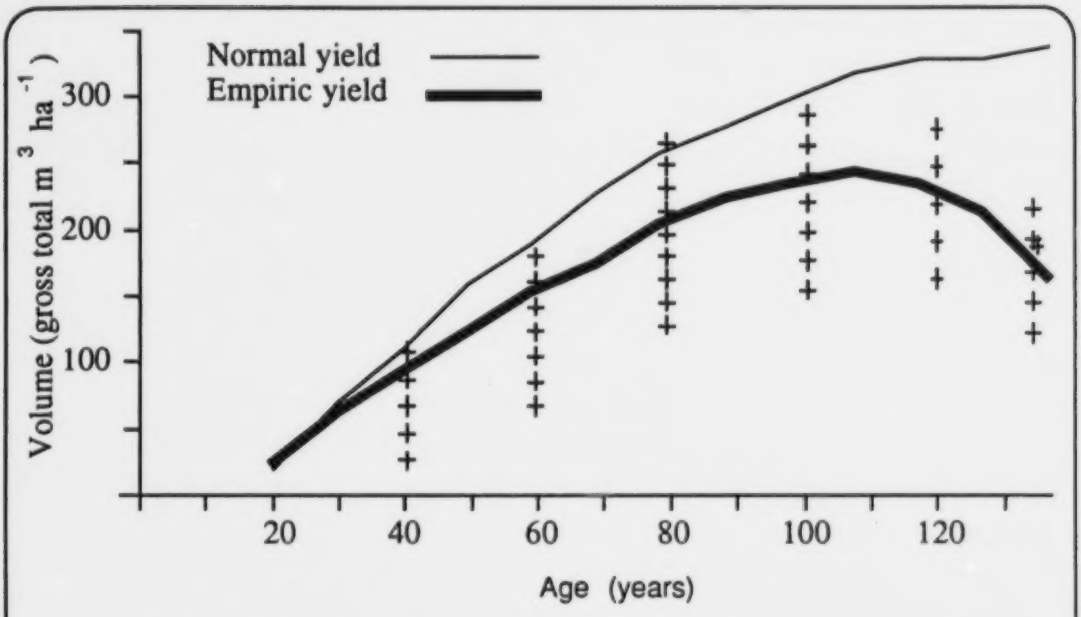

Figure 6. The derivation of an empiric yield curve from a normal yield curve for spruce site class 1. The crosses represent individual stand volume estimates. See text.

for all stands on all site classes in the working group.

These yield curves are used in the forecasts of volume to be recovered by harvesting the allocated hectares in the planning process. Specifically, they are used in: (i) Table 8 of the 1977 Manual of Forest Management Plan Requirements, (ii) forecasts of age-class structure change made under that manual, (iii) volume forecasts for harvest volume in Table 4-2 of the 1980 Forest Management Manual, (iv) forecasting procedures in the Appendix of that Manual, (v) the new Timber Management Planning Manual, and, (vi) OWOSFOP forecasts. The yield tables are produced as a standard FRI report (number 5) and appear as the estimate of volume per hectare calculated for a 20-year age-class in a working group.

Values given in the empiric yield tables are for the working group as a whole. Thus, the volume represents the total for all species in any mixture that is assigned to a working group. If a stand is a mixture of spruce, jack pine, and poplar, in the proportions 50:20:30, total volume of all species is calculated for the combined stocking as if the stand were entirely spruce. Most volumes used in management planning are working group volumes (ie., combinations of species) and not species volumes. Where species volumes

are given they come either from scaling records, or they are calculated from the working group volume proportional to the species contribution to total stocking. There is a need for variable-density, and variable-species-mix yield functions that permit a more realistic representation of what is out in the forest.

Most yield curves used in the cases examined showed the decline in overmaturity evident in the empiric curves in Figures 5 and 6. In technical terms of calculation, the lower volume at older ages results from lower stocking in stands contributing to that part of the curve. Unit Foresters managing the forests examined understand that low stocking at older ages to be the result of stand break up. Specifically, they do not believe these stands will increase towards normal stocking if left to age unharvested. In five of the six plans examined, this break up was of concern to the Unit Forester because of the way it influenced the availability of volume from the area allocated for harvest. Particularly, there was concern about the earlier break up on better sites and this had been studied in at least one case. The concept of keeping the best sites in production while still meeting the letter of the oldest-first rule was satisfied in these cases by defining separate forest units based on site class as subsets of the working group.

While this approach to handling volume may meet the requirements of the present timber management planning system where volume does not play a role in management design, it is not an adequate link between area and volume in terms of designing management to meet the prime objectives as stated in the management plans. Industry particularly needs much more realism in the area-volume connection to permit industrial planning.

Although Ontario was the Canadian leader in the development of yield tables, problems and approaches to management have outgrown the present tools. There is no systematic mechanism in place to discover if treated stands, whether treated by harvesting or by conventional silviculture, are actually growing along the current yield curves. Plantation volumes are currently forecast using the empiric curves for the working group (or forest unit) as if they were natural stands in the working group. There is a need for yield tables (or more realistic application of existing ones) that are not only a more realistic representation of local volume development in a stand over time, but also reflect quality of the material in the stand. There is no rational way at present to forecast sawlog availability over time. There is a need for a

Provincial strategy on growth and yield information development. The greatest care is needed to ensure that implementation of any such strategy remains firmly rooted in the real purpose of using this information in management design. It is not just more yield data that is needed, but specific information, in particular forms, that permits more rational linkage of area and volume in design of forest management. If the process becomes separated from the users there is high likelihood that it will become an exercise in the administration of yield data, rather than the creation of better yield information.

A better approach to site classification or characterization is needed, both in terms of the volume calculation, and in terms of designing silvicultural regimes. Current estimation of site relates to volume production. Site also influences the choice of silviculture and its efficacy. Site in this context appears in the ground rules and silvicultural guidelines in a form different from the conventional height-over-age of yield tables. There is a need for a systematic approach to site as it relates to silviculture and to logging. One FMA examined had added a site code locally determined by photo-interpretation of each stand in order to characterize it with respect to logging and silviculture. There are some interesting concepts of site emerging in the field, and these should be encouraged. Perhaps when the ideas have evolved somewhat, a centralized collection and unification of concepts would be appropriate, but at present such an approach seems certain to become an administrative exercise that loses track of the real issue.

OWOSFOP

OWOSFOP (Ontario wood supply and forest productivity model) is a tool used to forecast systematically change in forest structure over time as the result of implementing a particular set of area regulation rules. The process takes the current age-class structure for each working group on a Management Unit and updates it into the 'future' by five-year steps accounting for area that would be harvested in that period by removing it from the oldest age classes and designating it as cutover that must begin growing again. By using empiric yield curves for a Unit, and relating area in age-classes to the yield curve, the OWOSFOP model also provides a forecast of working group volume availability over time by calculating the volume that would be generated by harvesting the designated area of each working group.

The process of calculation is a straightforward representation of aging. As noted in discussion of forecasts, if the area removed by harvesting in the calculation is equivalent in size and age-class to that which would be removed in the real world, the forecast is a reasonable prognosis of age class development. If there is not consistency with what is being implemented in the real world, the forecasts are not credible. There are problems with the way area of harvest is entered in these calculations as oldest first and harvest of100% of the allocation. Also it is clear from previous discussion of yield, that the yield curves used in such forecasts are crucially important to understanding the Ontario wood supply future. OWOSFOP uses averaged empiric yield curves for a working group (or forest unit) for each Management Unit under study. OWOSFOP ignores geographic reality in the sense that it does not distinguish between two stands of the same age that are geographically at opposite ends of a Mangement Unit. It has this feature in common with all such procedures, whether they are computerized or not, but there is good (if cumbersome) geographic control in the actual application of management design at the Unit level.

The procedure of calculation is sound, and the tool is adapted to area regulation, but it is not well-used in management planning in the OMNR. There is in fact a willingness of many to use vague principles (eg.,"area regulation is best") rather than try to come to grips with understanding the dynamics that control the unfolding future in a forest. There is also a lack of accessibility of Unit Foresters to the tool because it is currently based in Queens Park. They need direct access to the tool, with programmer support, for the tool to achieve its greatest value. The point here is that there exists a tool that permits systematic examination of reasonably possible futures that might result from the implementation of management, and it is not being used effectively. Particularly, this tool offers substantial advantages in establishing the area-volume connection as it relates to planning issues (eg., surplus). For the tool to have full credibility, the issues noted above with respect to realism of area harvested and yield curves need to be addressed.

To get maximum value from OWOSFOP, attention should be given to simplifying the output, particularly to putting it in a form suitable for answering questions a Unit Forester might ask when reviewing a forecast during design stages of management planning. Similarly, volumes should be expressed by species and not by working group since the latter is misleading in planning. All of the data exist to track actual depletions in the calculation

so that it is always up to date. This could be a sound planning tool, and a sound tool for tracking real performance to give an indication of the contemporary state of the forest.

OWOSFOP should be used as a planning tool to examine various possible futures that might result from various possible management regimes, and it should be used to illustrate the probable outcome of implementing whatever plan is chosen. It should be used with data that reflect what actually happens on the Unit, and not an imaginary or theoretical implementation (eg., full allocation). For example, it could provide a realistic picture of change in the age-class structure over time by using a realistic harvest rule. OWOSFOP could be a significant design tool as a credible bridge between area regulation and volume consumption. This is a crucially important point. Since management will be designed and implemented by area, there must be a consistent forecast of volume availability if the plans are to have meaning with respect to their prime objective, volume sustainability. With little modification, proper use of this tool would allow systematic (ie., approximately right) analysis of future availability of volumes of different species with different quality parameters, a situation that would be much more amenable to rational evaluation of surplus than the current basis of surplus area. The use of OWOSFOP should be localized to the Management Unit level because this is where it can be of greatest use, and because this is where it can most safely be applied in terms of matching reality in the forest. Finally, it defeats the purpose of a forecasting tool to state in advance which plan, and which forecast, will be chosen before they are even calculated. For example, the Manual calls for three different (unrealistic) forecasts using OWOSFOP, and states before the fact which one of them will be used in managment design.

FORECASTS FOR THE UNITS EXAMINED

For five of the Management Units examined, a version of the OMNR OWOSFOP that forecasts in terms of species volumes rather than working group volumes was used to make a forecast of the results of 'implementing' the current Management Plan. The standard data base for each Unit was used, and the calculation rules followed the standard procedures. Specifically, the forecasts were for full-allocation, oldest-first, full-acceleration, regeneration as specified in the plan, and the empiric yield tables for the Unit. Some results of these calculations are presented in Table 2. The table shows, for each Unit, actual harvest volume by species reported

from scaling for the five-year period 1981-'85, and forecast wood volume that will be made available by harvesting the area designated by area regulation in each of eight 5-year periods into the future.

One Unit (Minden) is managed partly on an even-aged basis and partly on an uneven-aged basis, and direct volume forecasts could not be easily calculated. However, the plan for that Unit noted that the land base could reasonably be expected to support about one-half the volume target assigned to it by the SLUP and DLUG processes. Of five Units where systematic forecasts were possible, two show future surpluses of wood volume relative to current consumption levels, and three show future shortages of wood volume relative to current consumption levels for some working groups. Note that there is always area available for harvest as strict area regulation was followed in the calculations. The differences in volume availability over time shown in the table result from accelerated harvests and from variations in the age of stands that make up the area allocated for harvest over time.

Forecasts for the Plonski Forest Crown Management Unit show shortfalls below current harvest levels in available volume of jack pine, spruce, and poplar. While harvest area for these species is sustainable, the current level of industrial consumption in volume will not be sustained inside the 40-year time horizon. The volumes actually recovered by harvesting the allocated area in the period 1981-'85 were substantially larger than forecast to be available for that period in the1978-'88 Operating Plan for the Unit, but not even those lower volumes appear sustainable in the future. The Dryden Crown Management Unit appears to have a substantial surplus of volume above current industrial consumption. This Unit reports harvesting 78% and 87% of the allocated jack pine and spruce working groups respectively over the last five years.

The Iroquois Falls FMA shows a future surplus of volume above recent consumption levels. It is of interest to note that the volume available in 40 years time from harvesting the full allocation area is forecast to be about 70% of the currently available volume. Since the Management Plan shows an increase in consumption, there is a convergence of supply and demand. The Lake Nipigon FMA shows sharp declines in wood volume available over the next 40 years, with apparent shortfalls in spruce at that time. The English River FMA shows a steady decline in the volume of wood available, but a continuous surplus of volume in the forty-year period relative to current

consumption.

Interpretation of these forecasts requires care. They assume: (i) harvest of the full allocation of all working groups every year, (ii) the oldest stands are always harvested first, (iii) full acceleration in area regulation, (iv) regeneration as specified in the plan, and (v) future stand development with respect to volume follows empiric yield curves. They represent an explicit statement of the implicit wood flow assumptions in the OMNR planning process for these Units. Beyond that, the above noted shortcomings in the way these forecasts fail to realistically mimic events in the real forest makes interpretation tenuous. One point, however, is clear. In these five cases if the management plan is precisely implemented, and the future unfolds precisely as laid out in the plan, there is substantial doubt as to the extent the first objective of the Management Plan, that is meeting industrial wood volume needs, will be met. It is of interest to note that in this time period none of the problems of volume availability are attributable to regeneration. They are entirely functions of how the existing forest is scheduled for harvest.

The forecasts show how use of accelerated harvesting results in a decrease in wood volume availability over time. They also show that present area surpluses may be more apparent than real. There may be hectares surplus to current harvest capacity, but it is not clear if there is, over the next 40 years, volume surplus to the capacity of industry. Since the prime objective of timber management, as expressed in the plans, and as expressed in the various planning documents, is maintenance of the industrial base by providing for continuous flow of raw materials, the meaning of such forecasts as they are made for each Management Unit deserves urgent attention.

FRI

The Forest Resources Inventory is an extensive survey of the forest estate. By means of photo-interpretation, maps showing working groups as polygons are created. A small amount of ground sampling is carried out to establish the validity of the type designation of the polygons, and to reference the age of typical stands. Photo-interpretation then assigns an age to each stand on the basis of similarity of appearance with respect to the typical stands. Gross total volume for each stand is determined from normal yield tables (Plonski, 1981) using the photo-interpreted species designation, stocking, and age. There is a 20-year cycle of new aerial photography and

Table 2. Average annual scaled harvest volume for 1981-85 from five management units, and annual availability of wood volume for the next 40 years as forecast from the management plan data. Volume by species, in cubic metres.

PLONSKI FOREST CROWN MANAGEMENT UNIT

Species	Actual '81-'85	Forecast volume availability '86-'91	'91-'96	'96-'01	'01-'06	'06-'11	'11-'16	'16-'21	'21-'26
Pj	87 358	63 800	57 200	54 000	47 300	44 500	42 200	51 000	39 800
Sp	29 300	36 200	35 600	33 500	29 700	28 200	26 700	31 700	25 300
Bf	5 100	10 000	9 100	8 600	9 100	8 600	8 500	8 300	9 700
Con	121 798	110 000	101 900	96 100	84 800	80 200	76 100	90 900	72 000
Po	52 200	24 000	24 000	23 700	21 200	20 000	18 600	22 700	17 400

DRYDEN CROWN MANAGEMENT UNIT

Species	Actual '81-'85	Forecast volume availability '86-'91	'91-'96	'96-'01	'01-'06	'06-'11	'11-'16	'16-'21	'21-'26
Pj	30 500	58 100	55 500	53 700	50 600	48 700	47 500	52 100	45 800
Sp	11 700	41 300	39 200	38 300	36 800	35 900	35 100	37 600	34 400
Bf	0	7 500	7 400	7 300	6 800	6 500	6 200	7 100	3 600
Con	42 200	106 900	102 100	99 500	94 100	91 000	88 800	96 800	86 100
Po	2 300	35 700	35 700	35 700	32 300	30 400	28 700	34 300	27 200

IROQUOIS FALLS FOREST MANAGEMENT AGREEMENT

Species	Actual '81-'85	Forecast volume availability '86-'91	'91-'96	'96-'01	'01-'06	'06-'11	'11-'16	'16-'21	'21-'26
Pj	27 600	68 800	65 600	60 800	55 700	53 700	52 000	57 800	50 200
Sp	260 200	848 000	769 500	703 400	624 600	605 700	595 400	654 700	578 800
Bf	34 000	85 100	71 200	62 600	54 400	52 400	50 400	57 600	48 800
Con	321 800	1 019 000	906 300	826 800	734 800	711 900	697 800	770 200	677 700
Po	51 800	248 100	209 300	188 400	167 100	159 300	152 500	175 500	146 400

Table 2. continued

LAKE NIPIGON FOREST MANAGEMENT AGREEMENT

Species	Actual '81-'85	Forecast volume availability '86-'91	'91-'96	'96-'01	'01-'06	'06-'11	'11-'16	'16-'21	'21-'26
Pj	34 500	105 900	102 400	94 600	85 800	82 600	79 500	90 000	76 700
Sp	191 300	312 900	281 200	254 000	213 700	198 200	185 200	232 400	175 200
Bf	20 200	131 500	109 800	98 700	84 800	79 500	74 700	90 800	70 800
Con	246 942	550 300	493 400	447 300	384 400	360 400	339 300	413 300	322 900
Po	27 282	192 100	170 400	147 500	114 100	103 400	96 000	129 200	90 700

ENGLISH RIVER FOREST MANAGEMENT AGREEMENT

Species	Actual '81-'85	Forecast volume availability '86-'91	'91-'96	'96-'01	'01-'06	'06-'11	'11-'16	'16-'21	'21-'26
Pj	259 282	293 800	289 300	266 300	236 900	226 500	217 500	249 300	206 500
Sp	206 000	234 000	227 300	219 000	222 400	222 200	218 500	219 300	21 800
Bf	12 800	68 800	55 100	50 000	47 000	45 900	44 600	48 100	43 300
Con	478 099	596 600	571 700	535 300	506 400	494 600	480 500	516 700	464 600
Po	186	99 000	90 200	81 000	69 000	64 500	60 900	74 200	57 500

MINDEN CROWN MANAGEMENT UNIT

Species	Actual '81-'85	Forecast volume availability '86-'91	'91-'96	'96-'01	'01-'06	'06-'11	'11-'16	'16-'21	'21-'26
Pj									
Sp									
Bf	Data not available, unit managed partly on even-aged regulation and partly on uneven-aged								
Con									
Po									

interpretation across the Province (see OMNR,1978).

The FRI provides a general characterization of the forest which becomes the initialization for the forest management design process. The polygon designation fixes the area that will enter the area regulation calculation by working group. The age estimates establish the initial age-class structure, and consequently such factors as the degree of acceleration invoked in area regulation. To the extent the initial characterization of age-class structure is faulty, management design steps that follow will be in error since they will then be based on an age-class structure that is not the one that really exists in the forest. In the area regulation system of the OMNR, the volume established by FRI is not important in management design. However, it has been pointed out above that there should be a better connection between area and volume and this will require adaptation of the FRI.

From the point of view of establishing the initialization for timber management design, the Units examined commented on FRI with every opinion from adequate representation, to totally inadequate. In general, polygon definition was considered adequate, but the attributes assigned to polygons were considered only more or less reliable depending on the forest involved. The FRI appears to offer a less acceptable representation of the forest as the forest increases in complexity. This is a function of the FRI scale. In a complex forest the FRI scale does not capture a sufficient degree of the variation in stand structure. Further, on small Units the scale of FRI leads to an averaging of conditions which is not acceptable because of the limited size of the Unit over which averaging is carried out. The FRI was generally considered weak where selectively cut stands were involved. The opinion was that FRI was only marginally adequate for prescribing silvicultural treatment, and that additional local guidelines were therefore necessary.

The way in which FRI is used in the planning process there is no geographic specificity. For example, as long as a Unit of say 200 000 hectares has the 1 200 hectares of 81-100 year age class spruce working group listed by FRI located somewhere within its boundaries, it does not matter in the planning process if the 1 200 hectares are correctly identified on the FRI map. The way FRI is used in planning, it only needs to be correct on average over the total Management Unit, and that is what this broad survey was designed to be. For planning it is sufficient if, on average, there are in fact 1 200 hectares of

that age-class of the spruce working group somewhere on the Unit. To implement the plan, someone will have to locate specifically the 1 200 hectares of 81-100 year old spruce on the ground. In this context the credibility of the management design process hangs on the accuracy of the FRI characterization by working group and age-class for the entire Unit, and not on correctness with respect to individual stands, and in this respect FRI is not unreasonable.

The FRI could be greatly improved as a basis for management design by much greater attention to age, specifically to stage of stand development or relative age, and by more local application of the photo-interpretation. The conversion of the FRI 20-year age classes to 5-year classes in OWOSFOP, or in the hand calculations specified in the manuals, assumes all area in an age class is uniformly distributed across the 20-year breadth of the class. The application of age-classes in the forecasts of forest development can thus be significantly in error when that even distribution is not in fact the case in the real forest. The smaller the Unit, the more serious this problem becomes. Much more attention is needed to the establishment of age for each stand if the management design process (ie., area regulation) is to have credibility.

Although application of the FRI system has obvious weaknesses with respect to management design, acquistion of better stand-specific data could be more costly than the small gain in accuracy of the averages that are used in forest level planning would be worth. It would help to have the photo-interpretation done as locally as possible in order to take advantage of the experience of the Unit Forester, to give him experience in photo-interpretation, to have the best chance of catching local variations, and to facilitate field checking as the survey is carried out. The FRI process should be operated more closely to the Unit Forester than is currently the case.

The use of FRI in implementation of management is another issue altogether, because the benefits of averaging that operate in the design process do not apply in implementation. It is incredible to expect to estimate characteristics of a single stand with an area of the order of 200 hectares using a system designed to provide an average representation of an area of the order of 200 000 hectares. Yet this is frequently done. The FRI was not designed for the former, and not surprisingly, it does not do it very well. Such misapplication of the FRI has resulted in considerable confusion with respect to what FRI is, and with respect to its validity.

It is expected, and stated in the Manuals, that there will be an operational cruise to fine-tune the FRI to local conditions. This cruise is to be carried out in the implementation of management, and used to revise the FRI files so that they better represent local conditions. If such fine-tuning of the FRI has not been done, application of FRI in the implementation of management can be expected to give mediocre results.

It is downright silly to expect each individual stand as measured on the ground to precisely match the attributes assigned to it by FRI photo-interpretation. Consider a spruce stand on site class 1, at 0.7 stocking, and 110 years old. If the photo-interpretation was precisely correct, this stand would be assigned a gross total volume of 220 cubic metres. If the photo-interpretation erroneously assigned the stocking up or down a single class (0.8 or 0.6) the volume would be shown as 251 cubic metres or 188 cubic metres per hectare. If the age were erroneously estimated as a single class lower (80) the volume would show as only 177 cubic metres per hectare. None of these 'errors' make a significant difference on 200 000 hectares where the intent is to achieve a reasonable average over that area, with errors in one stand averaging, or balancing, errors in another direction in another stand. The FRI was not designed to be used in the implementation of management, and it is incorrectly applied when it is used in this respect.

Comparing the FRI photo-interpreted volume for a stand to actual volume harvested involves even greater differences, and has also led to confusion. Suppose a spruce stand has the FRI designation shown in Table 3 and that the designation is precisely correct. The FRI indicates a gross total volume assuming complete uniformity of the stand on the ground. However, no stand of 118 hectares is entirely uniform. In the case shown in Table 3, there are 35.4 hectares of unmerchantable poplar clumped within the stand, 2 hectares that cannot be harvested due to stand conditions, 7 hectares that cannot be harvested due to site conditions, an 18% reduction for trees of non-merchantable size included in FRI volume, and a 9% reduction for cull. Actual harvest volume of 157 m^3 ha^{-1}, or a total of 11 775 m^3 is recovered from 75 hectares (not the theoretical 73.6) and appears to be a small fraction of the estimated FRI volume, but the two represent different descriptive criteria of 'volume'.

In this case the actual net harvested volume is only 32% of the FRI gross total volume estimate, but it is 98% of the net harvestable volume, and it is

Table 3. The relationship of net usable volume actually harvested from a stand to gross total volume estimated by the normal yield table. See text.

FRI STAND DESIGNATION

211	stand number
Sp Pj Po 5 2 3	species code in proportion
110-18-0.7	age-height-stocking
1	site
118	area

		$m^3 ha^{-1}$		Total stand volume m^3
1 Normal yield table gross total volume		314		37052
2 Adjust for stocking of 0.7		220		
3 Distribution by species	Sp	110	12980	
	Pj	44	5192	
	Po	66	7788	
4 Estimated gross total volume				25960
5 Deduct for unmerchantable species; Po 35.4 ha		220	7788	
6 Deduct for area inoperable due to stand conditions; 2 ha		220	440	
7 Deduct for area inoperable due to site conditions; 7 ha		220	1540	
			9768	
8 Gross total volume potentially available on 73.6 ha		220		16192
9 Deduct for unmerchantable parts of stems to give gross merchantable volume; -18%		180		13248
10 Deduct for cull to give net merchantable volume available for harvest; -9%		164		12070
11 Actual scaled volume removed on actual area cut of 75 ha (Sp and Pj only)		157		11775

possible to get a variety of proportions between these extremes. This is true even if the FRI stand attributes are exactly correct, because the various values given refer to different definitions of 'volume'. Careless use of such numbers in discussions of utilization has been misleading.

The difference between gross total volume and net harvestable volume was examined on the six Units and found to vary significantly from Unit to Unit. There were several factors involved in this variation, the key ones being variability of stand complexity in the Units, variation in stage of development of the stands being harvested (older stands have more cull) and variations in harvest practice and equipment. There were no technical inconsistencies in the way harvestable volume was estimated, but it was done differently in every case because the forests and harvesting operations were different. Most companies have their own local volume tables and conversion factors for merchantability and cull based on actual recovery on-the-ground.

It is worth repeating that the FRI is not an unreasonable base as used in current forest management planning, but it was not designed for stand-level decision making and is incorrectly applied at this level. However, it must be noted that there is much suspicion of FRI expressed publicly. Some, perhaps most, of the comments reflect a poor understanding of FRI and its intended use, but the fact remains that credibility of the system has been challenged. In particular, industry sees itself as a major client for the data of FRI and wants an end to speculation about the reliability of the data. There are strongly held opinions in industry that until "the FRI question" is laid to rest, there will always be someone challenging decisions, resulting in diversion of scarce manpower and dollar resources away from serious management issues. In general, there is a need for the FRI to be updated in terms of the way in which it is currently applied. Particularly, there is a need for the data base to provide for systematic tracking of wood in its various raw material forms (eg., pulp roundwood, tree length, sawlogs, and chips) so that there can be more reasonable reconciliations of records at various stages of the planning and production processes. There is also a need to use FRI more effectively in its original broad sense as a way to assess the forest of a Unit in terms of its convergence on declared management objectives.

SILVICULTURE

Silviculture prescribed in the Management Plans was examined in the sense of whether the right silviculture is being applied, at the right times, in the

right places, and in the right amounts. The application of silviculture should be related to the relaxation of a constraint to wood flow. Silviculture is used to make more wood available over a shorter period of time than would otherwise occur without its application, and the use of silviculture therefore implies some future limitation to wood supply which is worth correcting at the cost of silviculture.

The choice of silviculture derives from ground rules on an FMA, and from silvicultural guidelines on a Crown Management Unit. These guides reflect reasonable (if broad) understanding of the various stand and site types, and of response of these to treatment. The choice of amount of silviculture is apparently based on budget available to carry it out. Specifically, there was no evidence in the cases examined that the amount of silviculture for the Unit had been determined with respect to some biological situation in the forest structure of the Unit as it related to long-term flow of raw materials. In all cases, explanations for the amount centered on the amount assigned as the share of the 'target' by the Region or District. Thus, the amount of silviculture undertaken is an administrative determination rather than one based on biological dynamics of the forest on the Unit. That is perhaps an overstatement, but only slightly. One would expect the amount of silviculture specified in a plan to be that needed to maintain a desired level of wood flow, but as has been seen wood flow was only superficially examined in the plans, and as a result silviculture type, and amount, were not chosen on this basis.

Under these circumstances, it is only possible to evaluate the effectiveness of silviculture in terms of whether it was sufficient in amount to meet the assigned target. It is not possible to evaluate whether the target itself is appropriate, since the basis for it is unknown, and in any event was not related to an analysis of needs within a specific Unit. However, this is silviculture practised in a local stand management context and not in a forest management context. Thus it is not possible to judge if the stand silviculture being applied is solving a forest management problem. In fact, since the only forecasts of silvicultural response used in the management planning process are based on exactly the same empiric yield curve as the relevant general working group, it could be argued that planning apparently foresees no wood supply problem to be resolved by application of silviculture.

It was clear there was need for regeneration effort in the cases examined. It

was clear that the Unit Forester was using the available budget to address what he believed were the most important situations, but there was no evidence of a process that ensured that the budget was spent on the sites and stands that would give the best marginal return in long-term flow of raw material from the Unit. The absence of simple planning tools to decide how much silviculture is needed, and to achieve cost-effective deployment of the available budget, are serious problems. It appears that silviculture has become a measure of administrative honour in the OMNR. What is needed is to get it back in the context of managing a forest on a Management Unit.

A related symptom of administrative influence on the handling of silviculture is the prevalence of reporting silvicultural activity in terms of administrative projects, rather than in terms of influence on the working group. It is possible to determine from the OMNR files what the total silvicultural activity is by any administrative grouping above the Management Unit with relative ease. It is difficult to determine the amount by Management Unit, and impossible to determine the amount by Management Unit relative to the Management Plan and its forecast changes in the working group, except by polling the individual Units. The easily accessible records show how much, and at what cost, but not relative to specific management plan objectives.

In developing measures of effectiveness of silviculture, as it is employed in timber management, the perspective should be at the forest management level, rather than limited to stand level response. In a forest management context the advantage of silviculture is not just that it 'fixes' one stand, but rather that, in so doing, it increases flexibility in dealing with all other stands in the working group across the whole forest. If the forest level context of silviculture is lost, the activity may well not appear cost-effective. When the value of the future result of silviculture in a single stand is discounted to the present, it is rarely possible to demonstrate cost-effectiveness on that particular hectare except with unrealistically low interest rates. However, in the forest context, the planting of say 400 hectares a year may make it possible to sustain a wood flow, from the forest as a whole, of 10 000 m^3 per year where there is only 8 000 m^3 per year sustainable without planting. That is, planting justifies an acceleration of harvest level because the rotation length has, on average, been shortened. The value of planting in forest management lies more in what it does for the productivity of the whole forest, than in its impact on the single stand.

The silvicultural approach in the cases examined is very much oriented to maintaining the same working group distribution as the natural forest. There are few attempts to convert, and only then where the original working group does not make effective use of the site, as with balsam fir. The stocking assessment and free-to-grow assessment procedures are well-designed, and provide a good base for re-entry of a stand to the MAD base.

It is not possible to state relative to the maintenance of the flow of industrial raw materials whether the silviculture that is being applied is adequate, inadequate, or excessive. The silvicultural effort is too strongly tied to administrative targets, and not at all to some feature of forest management control. As currently practiced, silviculture is not strictly speaking part of management design. It is more a 'given' that is added to the plan. There is a major need to return silviculture to a forest management decision base. There is need for a program to evaluate the response of treated areas in terms of the long-term impact on volume availability. The present evaluations are excellent for determining re-entry to the MAD base, but do not relate to any change in the long-term wood volume supply.

PRODUCT DISTRIBUTION

The objectives in the plans examined state, or imply, 'optimum' use of the raw materials in terms of value produced. It is implicit in the plans that the forest structure that is being created by management is one which will permit a 'best' mix of conversion plants to be sustained. There is no evidence that management is designed to get a forest that will deliver a best mix of products, and no evidence in any event that this best mix is recognizable. Harvesting patterns and silvicultural operations are prescribed without particular reference to potential products. In two cases, processing plants were identified as "liquidation operations". Small as they were, there was no sign of concern over future wood supply for these two plants.

Without a realistic measure of volume availability, it is not possible to address the issue of relative value of volume in different forms. It is not possible to forecast, nor evaluate, future sustention of processing plants that require any raw material beyond basic fibre. Specifically, there is no procedure in place for control of sawlog and pulp raw material to ensure that the best end use is achieved overall from a Unit. Access to available harvest area is assigned partly on the basis of product, but not with any objective means that permits evaluation of effectiveness. The records examined did

not provide much information on relative abundance of sawlog material, and that which existed was locally generated to suit local needs and was not part of the standard planning process.

This matter is related to the area-volume issue, but has broader implications. If there is a real desire to meet objectives of best end use, then there must be some measure of the value to Ontario of the various end uses. In most working groups examined, there will be few trees at the end of the first rotation capable of producing the conventional sawlog of today. Rotations are being chosen, with few exceptions, independently of a consideration of sustainability with respect to quality as represented by sawlogs. What is being done may be 'right', but there is no basis to demonstrate the issue one way or the other.

Procedures that have evolved with respect to product distribution appear to be designed to minimize current stress during assignment of harvest rights, rather than to extend the time over which a certain quality of material can be made available. Particularly, there are no procedures that would ensure identification of the 'proper' processing plant. The various forms of licencing used for smaller plants that traditionally require the higher quality material are neither clear in their operation nor do they give any security of flow with respect to quality beyond the efforts of the Unit Forester.

It is not possible to judge the degree to which Ontario is getting the best end use from raw material harvested from Crown forests. There is a need for procedures that systematically examine recent cut records, and forecasts in the management plans, to evaluate future availability of raw material of various qualities. It may be necessary to review industrial strategy in order to begin.

UNEVEN-AGED MANAGEMENT

Only a small portion of Crown forest is managed with uneven-aged regulation. The case examined was innovative and sound. However, there are no procedures for verifying performance in the use of uneven-aged or partial cutting approaches. At present all stands treated by selection or by partial cutting remain in the MAD base without any measure of verification. Given the danger of these practices degenerating into hi-grading, there is a need for assessment to assure that the quality of the forest estate is at least being maintained on areas managed in this manner.

PROTECTION

Use of any approach to regulation of growing stock, and particularly area regulation, implies that the forest will be protected to permit implementation of the schedule of harvest. The extensive OMNR fire protection system was not examined. Protection against unscheduled harvests by insects and disease does not appear as an item in the management plans in any substantive manner. A management plan cannot be implemented as written without protection from random natural harvests, and protection, where it appears in the plan, is not related to maintenance of wood flow.

The reduction in the MAD base for harvests by natural causes is sound since these are in fact harvests that do alter the productive structure of the forest, and since area harvested by nature is not available for harvest by man. Protection against these unscheduled harvests is mentioned in the context of "to be applied by the Ministry when necessary", but there are no guidelines with respect to what constitutes necessity beyond those stated for fire. Despite the pervasive implications of protection, there is no explicit planning in this respect in the plans examined, not even contingency planning. To the contrary there was a sense of resignation that protection, other than from fire, would not be afforded the forest except perhaps in token form. There was little sign of confidence the OMNR would have the will to protect 'when necessary'. This is not a good environment for long-term planning.

ADAPTIVITY IN MANAGEMENT DESIGN

The most important feature of any control system is its feedback mechanism. Feedback operates by detecting deviation from the planned direction or output, and activating mechanisms to change the direction back towards the one designated as the goal. A thermostat operates in just this manner to control room temperature by turning the furnace on or off as required. The quality of a control (management) system is largely dependent on the sensitivity and robustness of its feedback control mechanism.

In renewable resource management the feedback control concepts of engineering are embodied in adaptive management (eg., Holling 1981, Baskerville 1984). In an adaptive approach to managing a resource, the best current understanding of resource dynamics is used to set objectives and determine actions that should carry the resource towards those objectives. An adaptive approach acknowledges, however, that there is never complete understanding of resource dynamics, and consequently there will never be

complete control of the resource. This is particularly true in the case of a forest resource that is distributed across such enormous area that it is only possible to comprehend 'the forest' by looking at numerical abstractions of the real thing. An adaptive approach to management design proceeds on the certainty that understanding is imperfect and that the resource will not react to management interventions in the expected fashion. It therefore seeks from the outset to discover both deviation from the objectives and the cause of deviation. This search for deviation is the most powerful way to discover the basis of resource dynamics in the context of the design of management interventions.

In the OMNR case, there are broad objectives with respect to managing the resource, and sets of actions are being taken to carry the resource towards the planned goal. There are few, if any, feedback checks to detect deviation of the forest from the objectives, or to direct a different set of actions to correct for the deviation. There is, in effect, no systematic approach to the determination of efficacy of Crown forest management in Ontario. This is true at the level of the Ministry in a general sense, but true at the level of the Management Unit only in the formal sense. This is one of the most prominent manifestations in the OMNR of the primacy of administration over management. The 'system' reports in an administrative sense how much was done, and the measures of effectiveness relate to budget that was spent, not to what was accomplished in actual resource control by the action and expenditure.

Although the planning documents make reference in one way or another to the ideas of feedback control and adaptivity, there is no evidence of use of these in actual operation of the OMNR with respect to managing renewable resources. Instead, the OMNR system has acquired many short-term targets, independent of resource dynamics, and with great administrative pressure to meet these. The system resists any suggestion that the action set (target in OMNR) should be changed even when the action clearly is not resulting in the objective being met in the forest. There are really two problems here. First, there is no adequate system of feedback control to cause the OMNR programs to adapt over time as the resource changes in response to management, and as the Ministry learns. In fact, the absence of such a mechanism greatly limits the ability, and opportunity, of the Ministry to learn. Second, there are no substantive resource management goals at which to 'aim' the forest. For example, there is overwhelming concern in the Ministry with getting the full

amount of planting done each year, but nowhere is there documentation that evaluates the need for planting so that the amount can be kept in the context of managing specific forests on Units towards a defined objective structure. The resource management objectives are so broad, and inexplicit in their use of principles, they are ineffective as real guides to management design. This is somewhat like walking up to a thermostat on the wall and saying "...keep the room warm while using sound energy conservation principles...", but not setting the desired temperature!

Much has been written about feedback control in resource management, and about the need for adaptive approaches to resource management. This is not the place for an essay on those topics, but it is clear that the OMNR could use a major injection of the adaptive approach. A major injection will be needed to overcome the 'steady as she goes, do it by the book' approach that has become administratively entrenched.

III-TIMBER MANAGEMENT IMPLEMENTATION

The implementation of Crown forest management in Ontario is characterized by variability. To begin with, there are three similar, yet different, broad objectives in the Production Policy and its targets for the year 2020, in the SLUP, and DLUG with their targets for the year 2000, and in the Management Plans for the individual Units. None of these is stated in a sufficiently measurable form to judge management design or progress in implementation in an unambiguous manner. The prevalence of goals, targets, and general statements of principle that are not related in any cause-effect way to broad objectives further complicates the matter. Even the land bases are different amongst the various statements of goals and objectives, and only at the Management Unit level is there a plan of action related to a specific piece of the total resource. Curiously, this is the only level at which it is not possible to easily recover general 'performance' data that relate to implementation of management of the resource.

The Management Units were surveyed with a questionnaire designed to get information on the relationship of recent harvest levels to planned levels, and recent levels of silvicultural activity relative to planned levels. Some 80 Units replied including: 52 active Crown Management Units accounting for 8 581 200 hectares of productive Crown forest, 19 FMA's accounting for

9 439 800 hectares, and 9 Long Term Licences acounting for 3 629 800 hectares. This represents 60 % of the total area of productive Crown forest in the Province and 82% of the Crown forest with currently active management status (plan either current, runout, or outstanding, Table 1).

With respect to harvesting, the survey shows that there has been a substantial under-cut of the allowable area on the 80 Units in all except one working group over the past five years (Table 4). In this table the allowable annual depletion shown is the total from the Management Plans for all Management Units reporting for each working group, and the harvest areas are the actual total area reported by those Management Units by working group expressed for ease of comparison as a percentage of the allowable. On average, the softwood working groups have been harvested on these Units at a rate of 49% of the allowable annual rate of area depletion, and the hardwood working groups at an average of 40% of the allowable rate. The two predominant softwood working groups, spruce and jack pine, have been harvested at 47% and 55% of the allowable area respectively.

The volume associated with harvest of the total allowable area is listed by working group in Table 5, along with the volume, by species, recovered from the area that was actually harvested as reported in scaling returns, and expressed as a percentage of the total allowable for the working group. On average, the softwood working groups on the reporting Units have been harvested at 50% of the amount forecast to be available from harvesting the allowable area, and the hardwood working groups at19% of the allowable.

Note that the 'allowable volume' for a working group is based on all species on the area of the working group allocated for harvest. In the context of 'allowable volume' the species codes in Table 5 represent working groups. The scaling returns give volume by species, and hence the species codes in this context actually represent the species themselves. Thus, for example, Table 5 shows that there was a volume of all species totaling12 134 400 m^3 on the area of spruce working group allocated for harvest, and that in 1980-81 the actual volume of spruce scaled (from all working groups) was 52% of that total. This is a strange mixture, but it the best that can be done given the nature of the OMNR data base.

The high percentage of hardwood working group area harvested in comparison to a low percentage of the allowable volume suggests hi-grading

in these working groups.

The data presented in Tables 4 and 5 are averages over all 80 Units reporting. There was a high degree of variation amongst the Units as shown in Table 6. This table shows, by number of Units reporting, variation of the 5-year harvest of area relative to the allowable area. For example, in the spruce working group the table shows that 18 Units harvested only 0-20% of the allowable area over the period 1981-'85, 17 Units harvested 21-40% of the allowable area, and so on. The table illustrates the meaningless nature of averages for the Province. For every working group there is at least one of the 80 Units that has harvested in excess of 100% of the allowable area, and there are at least three Units that have harvested as low as 20% of the allowable area!

The information in these tables should be interpreted cautiously, and in the light of the comments earlier in this report with respect to the measures involved. For example, the allowable harvest area listed is the amount determined by full acceleration of the cut, which is larger than a normal harvest, and which is not necessarily consistent with markets.

Tables 7, 8, and 9 present similar analyses with respect to silvicultural activity on the 80 Units reporting. Table 7 shows the total area of planting as specified in the Management Plans for those Units by working group, and the percentage of that total achieved in recent years. On average 48% of the planned level of planting was actually carried out in the softwood working groups of the reporting Units, and 31% in the hardwood working groups. Table 8 shows all other silivicultural activities in the same format as Table 7. Table 9 shows the variation across the reporting Units in terms of the percentage of the planned planting actually carried out. For example, in the spruce working group 28 Units reported carrying out only 0-20% of the planned planting, 6 Units carried out 21-40%, and so on. Again, this format is designed to illustrate the considerable variation across the Units, and indicates a need for caution in generalizations. The tables presented here give an indication of how much silviculture was carried out, but do not indicate what the effect of this silviculture will be on future wood supply. As indicated previously, the need for silviculture in terms of future wood supply has not been established in a conventional cause-effect manner in the plans, and this prevents evaluation of implementation in that context.

While the data in the tables suggest there is under-performance in both harvesting and silvicultural activity, extreme caution should be used in their interpretation. Particularly the data cannot be applied to a specific Unit. These data, separated as they are from any cause-effect connection to objectives, represent an insufficient base to pronounce on the status of forest management as implemented in the province. The data show, at best, the need for a more rigorous analysis of plans relative to on-the-ground performance, and relative to the realities of the market world. Particularly, there is a general need for the development of realistic forecasts of what can be harvested and marketed, and what needs to be treated silviculturally to support this level of harvest, and this can only be achieved by analyzing up from the level of the individual Units. In doing this, the emphasis should be on performance of the forest system, and not on performance of the OMNR administrative system. For example, the recent 5-year reviews (OMNR, 1985) checked the administrative sufficiency of performance more than the management sufficiency. The relevant question is not "did they plant as much as they said they would?", but rather "is the amount of planting and the performance of those plantations consistent with correcting the wood supply problem that is being addressed?".

An issue in implementation is whether the Management Plan and the Operating Plan are meant to be documents that show someone "has considered" the appropriate things, or that these are working documents that are seriously followed in an attempt to control the unfolding future out in the forest. In one of the cases examined the Management Plan was a shelf document prepared to meet administrative requirements, and dutifully resurrected for purpose of display to this audit. In three cases the Management Plan was considered by the local Ministry and company people to be a working document. These people believed in what they had written into the plan, and had committment to making the plan work in the real world. Two cases were ambiguous. The situation with the Operating Plans was more complex. These must be working documents if there is to be any credibility whatever to the OMNR management system. To the people on-the-ground the Operating Plan is a working document, and in most cases there was the kind of easy familiarity with its contents that comes from everyday use. At this level, the Operating Plan is used as the place to start on-the-ground, and there was in all but one case good local tracking of the sorts of deviations from the plan that are forced by markets, weather, strikes, etc. Again at the administrative levels there seems to be little appreciation of the

real nature of an Operating Plan as something that is actually "made to happen" out in the forest. To the 'administrator', if it is by the book it is right, and there is no need to look at the forest, except vicariously through examination of numbers. There is a very real danger that insufficient administrative flexibility in modifying Operating Plans, in response to the realities of the world out in the forest, may severely hamper the implementation of timely and orderly management of Ontario Crown forests.

Table 4. Actual harvest area depletions totaled over 80 reporting Management Units, expressed as a percentage of annual allowable depletion by working group, totaled for the 80 Units.

Working group	Annual allowable depletion	Annual harvest depletion as % of allowable depletion					
		'80-'81	'81-'82	'82-'83	'83-'84	'84-'85	5-year average
	(hectares)			(%)			
Conifer							
Pw	6 619	68	65	57	94	101	77
Pr	1 110	65	61	67	61	59	63
Pj	42 555	63	55	39	54	66	55
S	111 487	50	45	42	49	50	47
B	22 322	47	31	34	31	42	37
He	635	63	66	39	87	118	74
C	3 465	44	36	37	40	36	38
total	188 193	53	46	41	50	55	49
Hardwood							
Mh	15 157	66	90	83	93	91	84
By	1 298	92	156	102	99	104	111
Po	64 431	33	32	30	47	44	37
Bw	37 032	24	28	25	27	32	27
H	8 161	42	16	19	27	22	25
total	126 078	35	38	35	46	45	40

Pw= white pine, Pr= red pine, Pj= jack pine, S= spruce, B= balsam fir
He= hemlock, C= other conifers, Mh= hard maple, By= yellow birch,
Po= poplar, Bw= white birch, H= other hardwoods.

Table 5. Actual harvest volume depletions by species totaled over 80 reporting Management Units, expressed as a percentage of annual allowable depletion by working group volume.

Working group	Annual allowable depletion	Annual harvest depletion as % of allowable depletion					
		'80-'81	'81-'82	'82-'83	'83-'84	'84-'85	5-year average
	(m^3)			(%)			
Conifer							
Pw	632 300	47	59	70	85	86	69
Pr	144 300	70	76	101	108	102	92
Pj	6 406 600	54	52	41	56	62	53
S	12 134 400	52	50	45	52	52	50
B	1 913 300	39	34	25	27	32	32
He	30 200	49	93	29	96	105	74
C	290 600	10	13	14	14	18	14
total	21 551 700	51	49	42	52	54	50
Hardwood							
Mh	870 000	25	35	29	34	66	38
By	98 600	67	76	16	23	29	19
Bw	2 643 900	5	5	5	6	9	6
H	808 000	22	32	22	35	39	30
total	12 439 900	13	17	15	21	28	19

Pw= white pine, Pr= red pine, Pj= jack pine, S= spruce, B= balsam fir, He= hemlock, C= other conifers, Mh= hard maple, By= yellow birch, Po= poplar, Bw= white birch, H= other hardwoods.

Table 6. Summary of the percentage of the annual allowable area harvested by number of Management Units, by working group. Averaged over the past years for the 80 reporting Units.

Working group	% of the allowable area actually harvested						Total
	0-20	21-40	41-60	61-80	81-100	100+	
	(Units reporting)						
Conifer							
Pw	5	3	5	5	4	11	33
Pr	11	2	1	1		6	21
Pj	13	10	13	8	9	9	62
S	18	17	17	14	5	6	77
B	25	9	12	7	5	6	64
He	16	3		2		1	12
C	19	9	3	2		4	37
Hardwood							
Mh	4	2	5	5	4	3	23
By	3	1		1	2	3	10
Po	26	23	9	11	4	6	79
Bw	31	21	7	4	3	3	69
H	15	2	4			1	22

Pw= white pine, Pr=red pine, Pj= jack pine, S= spruce, B=balsam fir, He= hemlock, C= other conifers, Mh= hard maple, By= yellow birch, Po= poplar, Bw= white birch, H= other hardwoods.

Table 7. Actual planting activity by working group totaled over 80 reporting Management Units, expresesed as a percentage of the planned amount totaled over 80 Units.

Working group	Annual planned planting	Annual planted area as % of the planned area					
		'80-'81	'81-'82	'82-'83	'83-'84	'84-'85	5-year average
Conifer	(hectares)			(%)			
Pw	2 163	28	50	48	63	68	51
Pr	617	34	38	43	26	21	32
Pj	14 231	41	45	48	60	78	54
S	18 907	33	29	37	56	81	47
B	4 388	24	17	29	41	54	33
He	25	44		72		80	39
C	158	7	33	38	33	20	26
total	40 838	34	36	40	55	75	48
Hardwood							
Mh	1 900	11	9	9	1	3	1
By	117	48	53	74	46	41	52
Po	7 081	24	40	40	38	42	37
Bw	2 729	7	71	45	4	28	30
total	12 327	23	32	32	33	33	31

Pw= white pine, Pr= red pine, Pj= jack pine, S= spruce, B= balsam fir, He= hemlock, C= other conifers, Mh= hard maple, By= yellow birch, Po= poplar, Bw= white birch, H= other hardwoods

Table 8. Actual silvicultural activity other than planting by working group totaled over 80 Management Units reporting, expresesed as a percentage of the planned amount.

Working group	Annual planned activity	Annual activity area as % of planned area					
		'80-'81	'81-'82	'82-'83	'83-'8	'84-'85	5-year average
	(hectares)			(%)			
Conifer	(%)						
Pw	14 466	41	39	45	48	57	46
Pr	3 368	52	53	55	56	91	61
Pj	82 925	39	31	40	32	30	34
S	95 130	36	35	47	51	60	46
B	5 485	69	62	90	94	104	84
He	876	17	15	12	43	48	27
C	825	9	28	32	21	21	22
total	203 956	38	35	45	44	49	42
Hardwood							
Mh	17 708	52	51	41	54	46	49
By	2 129	38	2	31	11	25	21
Po	15 631	43	49	46	54	65	52
Bw	7 165	21	15	34	42	40	30
H	5 273	15	32	18	36	21	24
total	47 206	40	41	39	49	48	43

Pw= white pine, Pr= red pine, Pj= jack pine, S= spruce, B= balsam fir, He= hemlock, C= other conifers, Mh= hard maple, By= yellow birch, Po= poplar, Bw= white birch, H= other hardwoods

Table 9. Summary of annuual planted area as a percentage of the planned area, by number of Management Units reporting, by working group. Averaged over past five years for the 80 reporting Units.

Working group	% of the area planned for planting						Total
	0-20	21-40	41-60	61-80	81-100	100+	
	(Units reporting)						
Conifer							
Pw	10	5	3	3	1	5	27
Pr	9	3	1			6	19
Pj	14	9	7	3	3	12	48
S	28	6	4	7	4	10	59
B	23	2	2	1	2	2	32
He	3						3
C	12					1	13
Hardwood							
Mh	1					2	3
By	2						2
Po	17	4	5	4	1	3	34
Bw	18	4	2	1	1	2	28
H	5						5

Pw= white pine, Pr=red pine, Pj= jack pine, S= spruce, B=balsam fir, He= hemlock, C= other conifers, Mh= hard maple, By= yellow birch, Po= poplar, Bw= white birch, H=other hardwoods

IV- BROAD PLANNING ISSUES

There are a number of issues with broad implications to planning in the OMNR that bear comment. Although these are more general than the technical issues raised in previous sections, they none-the-less have an important influence on the quality of forest management achieved by the Ministry.

TIMBER MANAGEMENT PLANNING MANUAL

The new Timber Management Planning Manual is clearly written and comprehensive in its coverage. Despite that, it is not clear whether it will be a "guide to minimum management reporting" as it states, or if it will become all that is needed to manage Crown forests in Ontario. Slavish adherence to the Manual would perhaps prevent major mismanagement in the Crown forests. On the other hand, slavish adherence to the Manual would also perhaps prevent the innovative application of technical skills extant in the Ministry to solve problems in their local context and achieve good management. To overstate perhaps a little, one has the impression that the local Unit Foresters and wildlife people would like to use the Manual as a guide (in the literal sense) to reporting, but not as a constraint on their design of management with respect to the unique situation of their Unit in terms of its forest, and the demands placed upon that forest. At the other extreme, some bureaucrats in the system will welcome this new arrival of the word that will, henceforth, be followed as the law.

Should a management plan demonstrate what can be achieved from the resource without intervention?, what is desired from the forest?, and what interventions, at what economic and environmental costs, would be necessary in order to get what is desired? Should a management plan show how output of the Unit can be increased for incremental increases in management input? These are not rhetorical questions, indeed they are questions that need considerable contemplation in the OMNR. No matter how comprehesive the Manual or its successor documents may be, blind adherence will not achieve socially acceptable answers to those questions. Merely following the Manual will, at best, result in filling in the blanks in a consistent manner for each of the 117 Crown Units, and will administratively homogenize all 117 Management Units so that they are all treated in exactly the same (mediocre?) manner. The Timber Management Planning Manual may be interpreted as a rulebook, but it states (page 29) that "...An analysis of the impact of such

differences [between plans and actions] on the achievement of the objectives and targets or the implementation of the planned strategies must be provided...". Here and elsewhere, the Manual enjoins users to apply intellect to the process rather than slavishly to follow rules. Regular comparison of 'planned' and 'actual' as required in the Manual should help make timber planning more realistic and prevent the administrative fixation on targets that presently seems to hamper (prevent?) a reasoned approach to timber management decision making.

The new manual has even less connection between area and volume than existed with previous versions, and in this respect it is seriously deficient.

There will be continuing change in the OMNR as new approaches to management design are developed. There is a sound basis from which to change in the Timber Management Planning Manual. The problem will be to prevent that manual from being preempted (prostituted) into a "TMPM dogma".

FOREST MANAGEMENT AGREEMENTS

A Forest Management Agreement is a Management Unit on which there is a contract between the Crown and a company for the company to design and implement forest management. The FMA's provide an improved connection of an industry to its wood supply, and have the distinct advantage of placing the harvesting and regeneration operations in a single set of hands. Although the 1980 Forest Management Manual spoke of a transfer of authority and responsibility in these arrangements, the full authority and responsibility appears to remain with the OMNR.

Sections 4 and 5 of the standard FMA state in succession that (i) the company will make the plan in accordance with the OMNR procedures, (ii) the plan will be submitted to the OMNR for approval, (iii) the OMNR will either approve the plan or specify necessary alterations, (iv) the company agrees to make specified alterations, and (v) the OMNR will approve the revised plan. It would appear that the company is constrained to perform precisely as an OMNR Unit in the Crown management system, and that no authority or responsibility has been transferred with respect to designing management of the forest. Indeed it could be argued that the FMA holder is an extension of the OMNR in the planning and management of these forests.

The FMA's have captured the substantial operational advantage of concentrating responsibility for carrying out harvesting and silviculture. Clearly the operational planning and execution of these two activities need to be tied closely because of the influence they have on one another. Company involvement in silviculture appears to be having an impact on the way harvests are being designed and carried out.

Despite the potential, the companies are strongly constrained and, like Crown Units, there is little acceptance of responsibility for the outcome as long as planning has been done by the book. Management Plans prepared by a company contain whole sections not written by company authors, but placed in there on instructions of the Ministry. A company does not feel great committment to such words, and indeed there were cases where inserted material was inconsistent with stated objectives in the Plan. This is limiting the development of some good ideas, for example, an "equivalent access cost" approach to the design and concentration of management effort.

A potential problem on the FMA's lies in the manner in which non-timber values are taken into account. A common response from a company person on this issue was that the company has no role in other uses. The company manages the timber resource for the Ministry, and the Ministry handles the non-timber uses. The companies do not maintain technical skills in the non-timber area, and have no contractual obligations other than to accept the OMNR modifications to timber management plans. On one FMA examined, the company had a comprehensive "environmental guide-woodlands operations" which, if less elegant in its wording, was an overlay in substance of the Ministry guidelines in this area. Even in this case the company bore no responsibility for non-timber values. It is difficult to understand how there can be integration of various elements of resource management when portions of the plan are inserted because "they want them there", and not because there is agreement on how this integration in the plan will achieve some common goal in the forest. If there is no integration in the writing of the plan, how can there be integration in its implementation, and in the results? The plan for an FMA contains management design for both timber and non-timber values, and has the appearance of being integrated. Yet, two separate agencies are bearing reponsibility for parts of one plan, a situation which invites ambiguity in performance.

The FMA companies appear to have done substantial long-term timber

supply analyses and industrial planning which has not found its way into the Management Plans. As long as companies are bound to operate precisely as bureaucrats within the OMNR system, the full potential of the FMA in linking the private sector and government in management of the resource will not be achieved.

FOREST SECTOR STRATEGY

The 1972 Production Policy Options for Ontario was a good document in its time, and the chosen policy of achieving a harvest level of 25 million m^3 per year by 2020 has been broadly followed. That policy paper was based on an analysis of demand, with a wood supply forecast that was technically acceptable at that time, but which would be considered trivial today. Application of the chosen policy in the Crown forest has been highly conditioned by contemporary markets, and it is unclear if there is a convergence of real market demand with results of activities to enhance suppply. Further, the 1972 strategy was based on the then current industrial structure, and an extrapolation of it into the future. All of this has resulted in a curious over-reaction where planning has been driven solely by anticipated long-term demand, and has not been connected to the short term realities of markets. Indeed the current planning process of the OMNR is virtually disengaged from real-time market influences.

The production policy expected an increasingly intensive approach to the management of all forest lands, Crown and private. Portions of the objective determined on this presumption were distributed downwards to the Crown Units, but there was little or no revision of these portions in the light of what the resource could actually produce as it was organized into Management Units. For example, the tables presented in section III of this report might be interpreted to indicate that Ontario could achieve the same level of production from a much smaller land base with the same silvicultural effort. This is a crucial point in the sense of the ability of the Crown forest to deliver the desired flow of benefits, and it relates to the overall cost-effectiveness of management.

There is an urgent need for a realistic analysis of what the Crown forest can produce. This analysis must start from the Management Unit and aggregate upwards. The existing targets that were distributed downwards are clearly inconsistent with the Management Unit capabilities and/or markets in at least the instances examined. This should not be surprising since those targets

were asssigned, rather than determined as biologically necessary, and feasible, on the basis of actual forest structure on the Units.

This raises the question: "Does Ontario have a procedure for achieving optimum allocation of the dollar and manpower resources available for managing the resource across the Units so that the best Provincial response is achieved at the least cost?". The answer appears to be no, since there is no evidence of realistic analysis of production possibilities. The evaluation of the best total response for timber production, wildlife etc., has not been sought. Rather, targets have been asssigned, whether or not these were reasonable biologically, reasonable in the sense of markets, or reasonable in terms of the budget available to carry out the actions.

In a sense, companies that use the forest resource are concerned with the operating plan and how it influences the quantity, quality, and cost of raw materials to them. The Ministry is concerned with meeting adminsistrative 'production' targets which are not strictly related to management needs. Too little attention is being given to the adequacy of design for long-term management of the resource.

All of this suggests the need for a forest strategy analogous to the 1972 production policy exercise, but working with real resource base information upwards from the Units, and ensuring that the result is a basis for assigning limited management manpower and dollars in a manner that does in fact approach yielding an optimum return.

This will require a forest sector strategy analysis to put various raw materials and other forest uses in better perspective. Such issues as best end use need more substance than the current words in the OMNR documents contain. In this respect the OMNR does not appear to be adequately connected to industry to ensure realism in such an analysis unless industry were active participants. Such a review could examine, for example, the effectiveness of intensively managing a smaller land base as opposed to extensive management of the entire land base as at present. In any event, such a review must include a rigorous bottom up analysis, so that the resulting strategy is in fact feasible with respect to implementation at the Unit level, both economically and biologically.

FOREST RESOURCE MANAGEMENT PLANNING

Forest management is the design and implementation of actions to change forest structure over time by intervening in forest dynamics so as to control the temporal and spatial development of a forest towards a specified goal as the future unfolds. Timber management is a subset of forest management. Wise forest management requires careful consideration of present and proposed future uses of the forest, and of the relationship between these uses and the evolving forest structure. In this context, Ackoff (1971) suggested that:

> "Wisdom is the ability to see the long-run consequences of current actions, the willingness to sacrifice short-run gains for larger long-run benefits, and the ability to control what is controllable and not to fret over what is not. Therefore the essence of wisdom is concern for the future. It is not the type of concern with the future that the fortune teller has; he only tries to predict it. The wise man tries to control it."

In planning the management of a renewable resource, the most crucial consideration is that of resource dynamics. The forest changes in character over time even without intervention, it also responds to interventions, and the causative base of these dynamics must be understood and recognized if management strategies are to have any chance of actually controlling the characteristics of the future forest. The effective way to approach this problem is to begin at the Unit level to examine the resource dynamics and discover the range of possible futures that reasonably could be reached. Analysis of resource dynamics leads to an array of possible futures, and these are then employed by the owners of the resource in an upwards review of social and economic feasibility as objectives. The process is usually iterated several times to find a match between what is possible in technical terms of controlling forest dynamics, and what is desired by the owners of the resource. The outcome is a management strategy which, if implemented as designed, has a reasonable prospect of delivering the desired future forest structure and associated benefit flows.

The reality of what will be achieved over time from a resource owned by society is conditioned by: (i) what society might like to have, (ii) what level of management society is willing to pay for, and, (iii) what is biologically possible given the dynamic structure of the specific resource in question. For management planning to have a realistic chance of successful implementation, complete consistency amongst the three is necessary. Great

goals that are biologically and/or logistically unachievable are a hazard to good management.

When asked how timber management planning was initiated, one Unit Forester replied "...take the bloody Manual and start". It became clear in that case that the process invoked much more thought than the reply implied, but there is a general absence of creativity in the linear top-down approach to designing forest management in the OMNR. There is also a substantial risk that the top-down planning process results in plans that do not represent what is biologically, or logistically, achievable in the forest.

In the very worst case the process of approving a management plan is a process of making it administratively acceptable. The process ensures the correct form of the plan, but does not ensure reasonableness of logic in developing the cause-effect relationships that link actions in the forest with desired results.

The absence of cause-effect connections in the OMNR planning is exemplified by a prevalence of statements of principle and by certain general phrases in the plans such that one encounters the same verbiage in plans written far apart in time and place. When the authors were asked why phrases, which clearly were not their own, were in their plans the usual reply was that it was required by Region. Such all-purpose word sets have been termed "boiler plate" and while it may sound good to the non-technical reader, boiler plate conveys absolutely nothing of substance. Some examples of nice-sounding, but meaningless, boiler plate are:
-"to manage the forest in a manner that upgrades the quantity and quality of forest products and meets long term needs of industry",
-"to maintain a forest which satisfies the requirements of regeneration, aesthetics, recreational values, fish and wildlife habitat, and soil and water resources",
-"to prevent long-term environmental damage by conforming to MNR policies and directives",
-"to provide for a continuous contribution to the economy by the forest-based industries, and to provide for other uses of the forest through sound forest management based on biological principles".
There is no technical substance to such 'good' phrases. Carelessly used in plans they give the illusion that implementation of the plan will result in these 'good' things, even when there is no cause-effect linkage between the actions

indicated in the plans and these 'good' things.

Planning was frequently referred to as a negotiating process. Clearly the benefits to be considered, and the relative weight given each benefit flow in the planning process should be subjects for public negotiation, but technical design of the control actions necessary to achieve these ends is not a process for negotiation. In technical planning the laws of nature must be obeyed. For the plan to have technical meaning there must be cause-effect consistency between the decisions and the expected outcomes in the context of resource dynamics and their response to interventions. This is not a matter of negotiating, it is a matter of biological reality.

There appears to be a belief in the OMNR that if a goal forest is negotiated and if the actions for reaching that goal are negotiated that everything will work. This approach can, and does, result in negotiating actions that are biologically incapable of reaching the goal. That is, the negotiating was on the form of the action, and not on the substance of its impact on forest dynamics. One planner was put off by a question about response of a moose population to a set of interventions outlined in a plan. The planner argued that it was "better to ask if the plan considered moose, than to ask how many moose were produced". Apparently in this case, as long as moose were 'considered' in the plan it did not matter if the moose population was impacted by the actions in the expected manner. In the view of this planner, responsibility appeared to end with "consideration". The exchange perhaps typifies a pervasive problem of lack of realism in the current planning process. The question is, does Ontario want to go someplace in particular with its Crown forest resource, or does it want to have readable, but non-implementable, plans that offend as few as possible? The answer is probably along the lines that Ontario wants to go some place in particular, using readable and implementable plans that offend as few as possible. Current procedures lack technical consistency and will not achieve this. Further, current procedures are highly susceptible to political, public, and bureaucratic pressures to engage in short-term satisficing (Simon, 1976) rather than long-term management.

The planning material of the OMNR frequently implies top-down approaches with little or no recognition of the underlying realities of resource dynamics that must be controlled in order to achieve the broad top level objectives. The new planning guide "A Framework For Resource Management Planning

In MNR" (1986) is a case in point. Following this framework will ensure resultant plans that are superlative for purposes of show, but not necessarily for implementation to achieve stated objectives. There is a tendency to discard the complexity of the forest, and of the cause-effect relation of actions to forest responses so that everyone can take part in 'managing'. In its 40 pages, the document never mentions the response of the resource to management interventions, nor even the matter of resource dynamics. It represents classic top-down planning. The concern in this framework is with the form of the plan, and not its substance. Following such procedures is likely to result in satisficing in the sense that the resultant plan will rationalize whatever it is contemporary society wants from the resource, but its implementation will not really try to control the future availability of benefits from the resource. The framework makes reference to the 'assignment' of objectives and targets without requiring any reference to how these relate to control of the future using a specific measurable set of actions to control resource dynamics.

While it is clear that a public resource should be managed for the public good, and that this will require public consultation to discover how the public values various benefits from the resource, this top-down-only approach of the OMNR encourages satisficing. This resolves resource allocation conflicts through contemporary compromise and restraint to status quo approaches. This is harmful in the long run as it fails to encourage creative exploration of what the resource is capable of producing by examing the system from the bottom up. For example, on the matter of designing resource management plans the framework says "Resource management planning is carried out to provide managers with directions on how resources are to be managed". If that statement is intended in the literal sense, then this is a dangerous document. The process described may be appropriate to discover what the public wants from the resource, and thereby to provide the manager with the goals towards which management should be designed and the constraints that must be observed in so doing. However, the procedures most certainly do not provide usable information on "how resources are to be managed". This may seem like a semantic difference, but it is the heart of real resource management. If the difference is not understood, the result is "administered resource use", and not "resource management".

The above may be an over-interpretation of what the authors of the framework document believe to be real management planning. The

document came to light late in this audit and the authors were not interviewed. However, no matter how pure the intentions, the result is a quality of resource management planning that ignores, or is unaware of, the fact that the resource really is a complex dynamic biological system.

A plan holds potential, but by itself is a sterile thing. The implementation of a plan to control resource dynamics is the active process that produces results in the resource. That a plan exists does not mean the resource is managed. Implementing a plan may mean the resource is moving towards management, but only if the plan is consistent with the nature of the resource dynamics. Planning is not the equivalent of managing, and planning and managing are not synonyms. In the literature, planning has been referred to as anticipatory to decision making (Mintzberg 1980) ie., not real decision making, but useful reasoning in advance with respect to the probable outcomes of a range of decisions. To make its planning realistic the OMNR must answer some questions with respect to the Ministry objective: is the objective of Ministry planning to get a target forest?, or is it to achieve favourable current public relations?; does the Ministry want management by design?, or management by the book?; does the ministry want management of the resource?, or does it want bookkeeping of the use of the resource?

SLUP and DLUG. The Strategic Land Use Plans and District Land Use Guidelines are comprehensive documents that provide guidance with respect to local goals and ways of achieving provincial resource management goals. These provide exceptionally good guidelines for localization of broad provincial generalizations. The one disturbing feature of these guides is the apparent belief of the authors that a plan, or a guideline, achieves anything in and of itself. For example, one of these guidelines continually refers to "the plan achieves x% of the target...". Obviously the plan does no such thing, although the implementation of the plan might. The difference is crucial because some plans are not implementable, and therefore they will not (cannot) "achieve their targets...", while others may achieve varying levels of success depending on the quality of the plan in terms of understanding resource dynamics, and depending on the way it is actually implemented.

The timber targets in these documents were established by distributing downwards a provincial wood production objective for the year 2000. It has not been possible to discover what the year 2000 objective was, how it was calculated, or how these volume targets were established, although a number

of different versions were encountered. In any event, there is no evidence of analysis from the resource base at the Management Units, upwards to the provincial level to discover if the resource dynamics can in fact support the stated goals.

The volume targets in the SLUP and DLUG appear to have been calculated partly by partitioning Management Units among Districts and Regions since there is not an exact overlay of Management Units on either the administrative Regions or Districts. This does not pose a problem for the establishment of administrative targets, but it does make it impossible to evaluate management progress with respect to these targets since all forest management is designed and implemented at the level of the Management Unit. Since the SLUP, DLUG, and management plans, are on different non-nested land bases, there is no unambiguous way to evaluate management progress, as achieved on-the-ground in the Management Units, with respect to the targets in the SLUP and DLUG. It is of course possible to report management activities by administrative District rather than by Management Unit. This describes 'progress' at the District level, if one assumes that all management actions in a Management Unit are independent of each other. This is not true, and if it was there would be no need to engage in planning. Yet this is exactly what is done. The logic of this is badly flawed since it implies that it is possible to set targets on one land base, design and carry out the management to reach these targets on a different land base, and then take only those management actions that overlay the first land base to evaluate 'progress'.

As the objectives of SLUP and DLUG are presently stated, it is not possible either to manage the resource towards them, nor to evaluate progress towards them. However, it is possible to report the work done in a format that gives the illusion that it is a measure of management progress. In any event, this need not be a major concern, because the real value in the SLUP and DLUG lies in the provision of local guidelines (in the best sense) for dealing with constraints and concerns in the pursuit of real resource management design and implementation at the Management Unit level.

INTEGRATION FOR OPTIMUM BENEFITS

The principle of integrating the management of timber and non-timber values is essential to the broad concept of forest management. When timber is managed by altering forest structure, other values are influenced.

Therefore it is wise to design these affects on non-timber values into the timber management plan. The OMNR planning process makes frequent reference to integration, and to attainment of optimum benefits from the forest.

The principle of optimization is that a measure of utility is established, based on the available quantity of preferred commodities, for example, on a combination of maintaining an even-flow of wood in cubic metres, hectares of deer yard available, number of user days available, etc. This combined measure of utility is dimensionless, specifically, it need not be a dollar value although that is common. It is only necessary that it reflect the current collective preference of decision makers for the various values in their various forms. The extensive literature on the powerful techniques of optimization includes applications to multi-value problems such as those faced by the OMNR. It is generally acknowledged that not all concerns can be captured in such a mathemetical algorithm, and in any event, it is certain that no decision maker should allow a decision to be made solely on the basis of such an algorithim. Both Zeleny (1982) and Dykstra (1984) deal with problems such as those faced by OMNR, and both recognize that all decisions, no matter how well-structured, have a fuzzy element to them that requires the intervention of human intellect to resolve. However, these authors, and others, argue persuasively that optmization tools can greatly facilitate the thinking process associated with decision making, particularly in terms of exploring the full array of management possibilities, and in reducing the display of this array to a feasible range from which managers can choose one for implementation.

In the literature, optimum is taken to mean best when compared to a single measure of merit, and subject to specified constraints (Zeleny 1982). The measure of merit can be either single- or multi- attribute in form, the only requirement being that it is in measurable units. It is this objective function that is maximized in the optimization routine. Constraints enter the determination as peripheral bounds, that is they are not maximized, minimzed, nor optimized, they are merely met in the sense that the solution stays within the bounds set by them.

Used in the OMNR sense, "optimum" and "optimization" are at best jargon, and bear no relationship to the substantial technical subject of optimization. In the OMNR sense, optimum means "feels pretty good for now, based on the

judgement of the people now present".

It is important to understand that the approach used in the OMNR planning is not achieving an optimum with respect to all values obtained from the forest. In fact, no real optimization process is used to determine the unique set of management actions required to achieve a defined "best mix" of benefits from the forest. There is an attempt to take 'best' local (site-specific) actions, but a principle of optimality states that when values are functionally connected, as in the present case, optimizing them individually in local situations (local maximization) will not result in the best total solution (optimum) for a Unit. Thus, on both grounds it is safe to say that an optimum mix of benefits is not being achieved. The major problems here are, first, because the non-timber values are stated in fuzzy qualitative fashion there is no defined "best mix" that can be used as a measurable target, and second, primarily because of the absence of measurable cause-effect relationships, the non-timber values are 'achieved' by applying constraints to timber values, rather than as part of a combined objective function. By their nature constraints are merely satisfied, in either mathematical optimization or in the real world, since there is no incentive to do them well.

There is no reason to expect that optimum value is being achieved from the Crown forests despite the frequent use of the word in planning documents. It would be possible to use an optimization approach, but it would be a drastic departure from the current scheme of informal qualitative judgements. It would not be necessary to convert everything, or anything, to dollar values to do the job, but it would require an explicitly quantitative statement of all the connections between the various benefit flows. In other words, it would require explicit statement of such things as how a particular measure of harvesting affects a particular measure of wildlife habitat, as opposed to the broad trivial statement that there is an influence.

It is not clear why there is ready acceptance of such statements as "environmental quality and integrated resource management objectives can only be stated in qualitative terms" (Timber Management Planning Manual, page 59). In a strict logical sense if these things are not in some way measurable, then it is not possible to know if, or when, there is "enough" or whether it is "better" or "worse". In reality, this means these important matters are left entirely to individual judgement, and are thus consigned to endless argument of the 'yes it is', 'no it isnt', variety with no real progress

towards improving the forest. The state-of-the-art in these matters is well beyond this stage, and an attempt to set attainable objectives would greatly enhance the focus of management programs. The isolation of timber management planning from these other concerns means that the other values can only enter the timber decisions, which are the only real control on change in forest structure over time, as constraints. They are not in fact part of a central objective.

V- INSTITUTIONAL ISSUES

There are a number of institutional issues in OMNR that strongly condition the environment in which forest and timber management are planned and implemented. These have to do with the way people work in the Ministry, and with reporting systems in the Ministry.

INFORMATION PROBLEMS

There are substantial problems in the Ministry with respect to handling information. In every case where information was sought by the audit, it was in existence, but the number of times when it was not retrievable in a usable form was alarming. It is exceedingly difficult to get clear data on many forest and timber management matters. As a simple example, the audit has four measures of the area in each of the six Management Units examined; those from the individual Management Plans, those from the Appendix of the Timber Management Planning Manual, those from the FRI files, and those from the Forest Resources Group files. For one of the six Units, the listed area is the same in all four places, the other five Units have different areas in at least one place, and one of them has four different values!

A fundamental problem in the OMNR is that information for the purpose of managing the resource has become lost in the effort to move administrative information up and down the hierarchy. The conversion of data to information is such that information is context-sensitive. The administrative system works on administrative data and information, not on management data and information. The two are deceptively similar, but they are not the same. While management information can serve some administrative purposes, it is rare that administrative information is useful in the design of management. Failure to make this distinction is leading to unnecessary

confusion about management on the Crown forests of Ontario.

The information on the maps at the Management Unit, and in the ledgers at the Management Unit, constitute the correct base for forest management information. Information retrieval at this level is archaic. The remaining information systems are designed to suit administrative functions, and are not particularly good with respect to containing useful and usable resource management data, or with respect to retrieval. As an example, the OMNR information system (using 'system' loosely) contains the amount of area harvested annually, and contains the amount of area that is shown in the various management plans as allowable for harvest. It is logical that these values would be compared in any evaluation of management progress. It is possible to retrieve either of these data, but it is not possible to retrieve them together. In fact, the simplest way for the audit to get this information in a usable format was to write each Management Unit separately.

In general, there appears to be a very good data base on the resource. The problem is that this data base is not amenable to interrogation with respect to management information. It is not easy to retrieve information from the Ministry data base except in an administrative format. Since an administrative format does not retain the connection between the design of a set of activities and their implementation, the existing information systems are largely unusable in the sense of managing the resource. A frequent complaint in the field was that data supplied to administrative levels have to be worked up for local use by hand because once they got into the computer system they became inaccessible to the Unit Forester for day-to-day planning purposes. Questions about the resource commonly received an answer to the effect that "we could add that up from the ledgers", a process every bit as cumbersome as it sounds. There is a good resource data base in the Ministry, but it has not been converted to a good resource management information source.

The existing information systems appear to have been constructed with a view to supporting requests for budget, rather than to evaluating effectiveness of management of the resource as it occurs in the forest. Particularly, there does not appear to be any substantive information system retrieval built around the Management Units. Summaries by such administrative units as Region or District are easily accessible, but few (none?) are available by Management Unit. Since the Management Units are

the only land base for which there is an identified management objective associated with an identified resource in a specific management plan, this means that it is not possible (or at least exceedingly difficult) in the OMNR to evaluate management at the level at which it is actually planned and executed. There is a major need for information retrieval that permits aggregation at the Management Unit level. The use of information in managing the resource is decentralized because of the resource distribution. A useful information system must recognize this reality. Queens Park, the Region, and the District do not use information to manage the resource, they are merely centres for storing and administratively reporting data. The need is to get usable resource information into the hands of the Unit Forester who writes and implements the management plan. It may be appropriate to have centralized compilation of information, but only if it is done so that it does not mask the information needs of managers. The resource information system must be made more readily accessible to the manager.

WHO IS RESPONSIBLE?

For management to be effective, there must be well-defined responsibility and accountability. In the cases examined, the collected participants in the planning process were individually asked who was responsible for the plan. The question was phrased in the context: "If the plan of management actions were found to be inadequate to the objectives of the plan, who should be held responsible?". Answers ranged from the Unit Forester who prepared the plan, all the way to the Minister. There were in-between answers, the most frequent being the District Manager. In every case, the Unit Forester accepted responsibility and accountability for the plan, but in no case was there general agreement that he was responsible and accountable. Each of the signatories to approval of a plan had their own view. Most believed they had provided advice to the person preparing the plan, most believed their signature indicated that the plan was consistent with planning rules in their area of interest, but few believed their signing necessarily meant that plan was 'good' in any sense beyond meeting minimum requirements.

In these discussions there was frequent reference to negotiated trade-offs. There was no general agreement on who was responsible for the overall efficacy of the management outcome in the forest as it is designed into the plan, and indeed a resistance to the idea of establishing personal responsibility. There was insistence that responsibility extended only to ensuring that the plan met the guidelines, and no responsibility was implied,

or accepted, that the plan, when implemented, would result in achievement of greater (optimum) benefits to Ontario in the forms stated or implied in the management objectives. The bottom line was that there was acceptance of responsibility only to ensure that the planning manuals were followed. As long as this was done, but implementation of the plan on-the-ground did not result in achieving desired objectives, that was the fault of the planning manuals. Several people stated explicitly that all liability for a 'wrong' plan lay with the planning manual as long as it was followed. This absence of a feeling of responsibility and accountability for controlling the actual resource, rather than just controlling the paper work, was startling.

The responsibility for quality of management plans in the OMNR is dispersed, perhaps to the degree that "where everyone is responsible, no one is responsible". The dispersed responsibility has resulted in considerable inflexibility. There is a prevalent attitude that all players must be involved at all times, not necessarily to get their technical input because this seemed seldom to be the case, but rather to get assurance that the book is being followed. With the exception of Unit Foresters, there was no real expression of responsibility, or feeling of accountability, for what actually happens out in the forest. The pervasive attitude was that as long as the rules (eg., public exposure) were followed, the job has been done, and any responsibility has been fullfilled.

The dispersed responsibility for forest management design and implementation has several implications to the quality of management actually achieved on-the-ground, and for the vigour with which the management plan is executed and supported. It was common to hear wildlife and timber people discuss particular tactics, in particular areas, in the context of at least a conceptual strategy that they had agreed to try and implement. Beyond that, the integrative discussion was always in terms of vague principles not specific to the Unit, and not even specific to a resource. The idea of negotiating a plan appears to have relieved everybody of responsibility, and left everyone more or less dissatisfied with what they were able to negotiate. This is partly a feature of the non-timber values entering as constraints rather than as parts of the objective function (in the sense of optimization) and partly that the technical base of the integrated aspects of the plans is invisible, and quite possibly inadequate.

Major changes are needed in the definition of responsibilities and accountabilities if consistently adequate resource management (and particularly timber management) is to be achieved. The Management Unit should be designated as the key level for all management issues. This is the only level where there is a plan related to a specified resource, and it is the only level at which these plans attempt to control actual resource development over time.

The Unit Forester is the person in the system who has direct contact with, and commitment to, the resource as it exists, and as it is being managed in the real world. Other levels may want to say they manage the resource, but they do so only in an abstract vicarious sense. The Unit Forester is the connection of the system with actual management of the timber resource; all the rest is merely administration to the management of the resource.

The current staff listing of the OMNR shows 197 professional foresters. Of these 75 (38%) are Unit Foresters assigned to Crown units. There are 54 foresters with one unit to manage, 18 with two units, and three with three units. Despite the doubling (and tripling) this leaves 18 of the 117 Units without a Unit Forester. The Unit Foresters have, on average, been on their present Unit for 4.6 years, with 52% of them serving in that capacity two years or less, and 67% serving five years or less. This situation is not conducive to the stability and understanding of the local resource that is essential to design and implementation of good forest management. Procedures for professional development in the OMNR should be modified to permit, and encourage, Unit Foresters to stay on a single Unit at least until the management plan they design goes through one period and an evaluation. The Unit Forester should be able to reach virtually the highest professional standing in the ministry without leaving the Unit. This is not a point of arguing for the Management Unit against the other organisational levels in a battle for administrative superiority. The Unit is the only management connection of the OMNR to the resource, and the Unit Forester is the only real resource manager in the system. The job must be recognized if it is to attract and keep people who can do it well. The partial 'dedication' of a lot of people will never be as effective in designing and implementing management as full dedication of a Unit Forester who is directly responsible and accountable for the quality of management on his Unit. This is true whether the Unit is managed by the Crown or by a company. The concept of a Crown Representative on a Forest Management Agreement is weak, and should be

replaced with a full Unit Forester. The only management link the OMNR has to the FMA's is through the Unit Forester. Other links exist as administrative connections only.

Responsible management of the resource will occur, or will not occur, at the level of the Management Unit. There should be a clearer designation of the Unit as the key to management design and implementation, and clear designation of the Unit Forester as the responsible and accountable manager of the Unit. The Unit should report to a single District, and the work of the Unit should be reported in total for the Unit within that District in the administrative reporting system. While management planning can be easily discussed, much in the sense of a parlor game that everyone can play, its actual design and implementation requires great dedication over long periods of time, and the present system of dispersed responsibility and minimum accountability is inadequate in providing of this environment.

A PROBLEM OF ADMINISTRATION

Large organizations tend to have problems of administrative inflexibility, and the OMNR does not appear to have escaped. The large geographic area, and the diverse nature of both the forest and the demands upon the Crown forest, necessitate a substantial administrative structure. However necessary an administrative structure may be, administrative functions do not add to the value of the resource. Throughout this report examples have been cited of the OMNR administrative structure pre-empting and/or frustrating management of the resource. This is a pervasive and diverse problem of serious proportions that is briefly summarized here. It will not be easy to correct this problem because reasonable solutions will appear to threaten existing administrative authority.

The administrative structure of the OMNR embodies both lineauthority and staff function from Queens Park, to the Regions, to the Districts. This structure, known as a matrix, is characterized by 'line' responsbility for carrying out actual tasks and 'staff' responsibility for technical direction on how best to do the tasks. In the OMNR case the line and staff sides of the matrix appear to have arrived at a successful mode of operation, although there is little distinction above the Unit Forester in the system between "management of the resource"', and "administration to the management of the resource".

Clearly management of a resource as widely distributed and diverse as the forests on 117 Crown Management Units requires extensive administrative support, but administering to the management of the resource does not, and cannot, accomplish management of the resource. There is far too little distinction and awareness of the differences among; (i) planning for the management of the resource, (ii) managing the resource, and (iii) reporting on activites related to management. The first and third items can be admirably executed without having much impact in terms of causing the actual resource to develop towards a desired goal.

A good example of failure to distinguish between managing the resource, and administering the budget, is seen in the application of the concept of management by results (MBR) in the ministry. Targets have been set and progress in 'management' is assessed in terms of the results obtained in moving towards these targets. For example, the target may be to plant 200 000 seedlings, and the progress or result that is reported, and used to evaluate performance, is the number of seedlings planted. There is no visible reference back as to why the seedlings were being planted in the first place, and no assessment as to how well the number planted were able to grow and thereby contribute to solving a specified resource management problem. An analogy in sales, the area where MBR emerged, would be for salesmen to report at the end of the week the number of calls made. In this sense a 'result' of 100 calls would be considered superior to a 'result' of 50 calls. Surely the thing that counts is the number of sales that were made! The application of MBR in the Ministry is similar to reporting the number of sales calls, rather than the number of sales made. The fundamental issue here is whether effectiveness of management effort is assessed in terms of solving a particular problem in the resource, or by planting a certain number of trees. Clearly the evaluation of adequacy will differ in the two cases. The administrative fixation in the Ministry with meeting targets irrespective of whether the targets are in the right place is alarming.

The over-concern in the OMNR with administering to management, at some expense to actually managing, takes several forms. Most common is a tendency for people more remote from the on-the-ground activity to seek consistency in form, rather than in substance. The correspondence files for management plans revealed, for example, lengthy arguments as to why depletion area and treatment area were not the same . The fact that they were not the same on the ground seemed not to be as important as insisting that the

books must show them as the same. In another case, correspondence over several months with respect to approval of a plan was bound in the front of the Management Plan for a Unit as one document. Only by direct comparison of the correspondence with the plan was it possible to determine that the plan had been revised to take into account the points raised, and that the correspondence was redundant. The case in point had 73 pages of apparent caveats to the plan. There were two items from Queens Park, four items from the Region, five from the District, two from a company, and two unsigned. All approval forms were signed, but all of the approvals bore some measure of qualification. Inclusion of the correspondence served no useful purpose, and indeed detracted substantially from understanding the plan.

The approval process for management plans is so administratively oriented, and so in search of administrative consistency, that substantial technical errors slip through readily. As examples, the audit found: (i) a plan with an error in the land base, (ii) plans that implied even flow of raw materials to industry with no check of this vital matter, (iii) an error in the working group land base used to calculate the allowable depletion, (iv) allowable depletion reported as a different amount in two tables in the same plan, (v) tables of surplus with arithmetic errors, and (vi) a calmly accepted error in a computer program that caused some 10 000 hectares of the land base for calculating allowable depletion to disappear. The point of this list is that the approval process allows significant management issues to slip by in error, largely because of a pre-occupation with the form of the presentation rather than its technical content of the plan.

There is a need for uniformity in the presentation of plans if there is to be reasonable comparability across the Province. That is necessary in order to establish technical adequacy of the overall management efforts. However, there was much complaint in the correspondence about non-conformity to the rules of presenting tables, but surprisingly little with respect to the accuracy and meaning of the numbers in the tables. Further, these files contained a disturbing number of instances where a directive was issued to make a 'correction' in a manner clearly at odds with wise management. Most of these reflected a lack of technical knowledge of forest management in a position distant from the forest.

The approval process for management plans has evolved into a proliferation

of paper. The caveats in the communications seem designed either to show that some issue has only qualified approval (posterior protection) or to prevent anyone from ever making a mistake related to the planning process. In either case, the process leads to involvement, however peripherally, of absolutely everybody, and while mistakes are still made, no one learns since technical responsibility and accountability has become so dispersed (often in the anonymity of a committee) as to be non-existent.

The audit encountered considerable concern within both the Ministry and in industry that administrative imperatives were resulting in reduced effectiveness in management of the resource. Industry cited cases where a somewhat anonymous committee made decisions and sent the Unit Forester to carry the message to industry. They argued that these planning teams often showed little understanding of the realities of forest operations. A particular problem in this respect is the reliance on "guidelines" of people remote from the resource being managed. Guidelines appear in many (perhaps most) cases to have evolved into laws that must be followed to the letter or at least reported in that manner. This rule-book approach has been called "Betty Crocker forestry", and for those who insist on doing everything by the book, the appellation fits well. There was evidence of work by people who used guidelines as guidelines, and who were functioning as good managers. There was also evidence of people who insisted on using guidelines as laws, and these people were functioning as bureaucrats in the very worst sense of that word.

A major problem with this administrative emphasis is that it stifles initiative. When a company or ministry forester finds "a better way", the innovation is resisted mightily by the system. In a world of management-by-filling-in-the-blanks there is little tolerance of the challenge of innovation in the number or shape of the blanks to be filled in.

Administration is properly concerned with budgets. In the present case, the evidence suggests that concerns over accounting procedures have taken the focus of the OMNR off management of the resource, and placed it on the administrative goal of acceptable accounting. Budgetary planning appears to override management planning.

There is a need for a review of administrative procedures with the intent of bringing the best impact of the OMNR staff on problems, rather than just

following guidelines and meeting short-term targets that have only weak (eg., in principle) connections to the world of resource management. There is a need to establish clear responsibility and accountability across the full range of the management process.

VI- SUMMARY

There is risk in attempting to summarize a situation as technically complex and geographically variable as Crown forest management in Ontario. Clearly the audit has not been able to cover the entire span of activity, nor the full geographic range. The 117 Management Units are not the same in terms of their forests, the use of those forests, nor the quality of management on those forests. Against this variable background the audit strived to obtain a comprehensive overview of how Crown forest management is designed and implemented. It is perhaps worth noting that reading and study in the order of hundreds of hours was necessary to gain sufficient understanding to begin the audit.

In general, the structure for managing the Crown forest is adequate, but it is not effectively used. The management plans contain the right topics, but the plans tend to be constructed by a cook-book approach, rather than with an application of intellect. As a result, the plans tend to be so general as to defy evaluation. The OMNR review process for management plans concentrates more on the presence and form of items than on the quality with which these are reasoned and on the internal technical consistency of the plan.

The objectives of forest management in Ontario need urgent attention. As stated, these tend to be vague principles of 'goodness' with little technical substance, or biological and logistical realism. Not surprisingly, management has evolved to a form where it is done in accordance with the book, and measured against work targets, with little or no evaluation relative to the stated objectives for the forest.

The many technical issues raised with respect to timber management design can be readily addressed with existing skills in the Ministry.

The problems relating to an administrative mindset dominating in the

Ministry are severe, and will be the most difficult to fix.

The most important remedial step is to establish the Management Unit as the basis of designing, reporting, and evaluating management. No manual will ever control the quality of decisions when judgement is involved, and judgement is inevitably involved in resource management decision making. It is essential that the system recognize the importance of the Unit Forester position, and attract people to the position long enough to acquire the understanding of the local forest necessary to making quality decisions. The Unit Forester should be clearly assigned responsibility for, and be held accountable for, management on the Unit. The Units should be assigned to a single District, in a single Region, so that administrative reporting does not continue to hide real management.

The absence of a technically sound approach to integration of timber with non-timber values is a more serious problem that will require considerable change in the system if the desired level of integration is to be achieved. The approach used to integration of timber with non-timber values is based on local judgement with no objectively measurable standards. The integration being achieved may be good, and it may not be, but currently that is up to anyone to decide for themselves. There is no agreed upon way to assess the success of integration. The approach to discovering public opinion about planning issues is open, but it is being used to justify actions (or inactions) rather than to determine what values the public expect from the resource so that management can be designed to achieve those values to the extent possible. Much of the planning material in this area would be better described as creative writing about the resource than as a realistic attempt to control resource development over time to achieve objectively stated values.

Area regulation is well-suited to the timber management problem and is reasonably applied. The major need is for a realistic connection between area and volume. Processing plants for which timber management is undertaken consume volume and not hectares. The forecasting procedures used in management design are inadequate and give an unrealistic view of the probable future that will occur if the plans are actually implemented. This is particularly true with respect to the availability of industrial raw materials. The forecasts are inaccurate in the manner in which they depict the approach of the forest to normality, and inaccurate in their depiction of the availability of raw materials for processing plants.

The FRI is reasonably used in the current management design system, but that system needs overhaul, particularly of the area-volume connection, and the FRI will have to be adapted to suit its use in a revised approach. The FRI has been substantially misused in terms of estimating individual stand volumes, and this has resulted in considerable confusion over the validity of FRI.

The forest management system has insufficient internal evaluation and adaptivity. Partly because the objectives tend to be qualitative, and partly because the measures of progress are not related to the objectives, there is no adequate mechanism to detect failure of the forest to approach the objectives, nor to initiate redesign of management to correct its influence on development of the forest system.

Current annual harvest levels are at about one-half that shown as allowable in the plans, and current levels of silvicultural activity are similarly at about one-half the level indicated in the plans. There is great variability from Unit to Unit in these respects. There appears to have been little attention paid to the pervasive role of markets in the design of management with the result that plans show unrealistically high levels of both allowable harvest and needed silviculture in working groups where markets will not support harvesting. Most departures from the plans appeared to be market driven.

The most important issue is not a technical one, but rather an administrative one. There is insufficient responsibility and accountability in the management system. The distinction between managing the resource, and administering to the management of the resource, both necessary and important activities, has been blurred in the OMNR to the point of being lost. The existence of an approved plan has become more important than the creation of a realistic plan that is technically consistent with biological and logistical realities in terms of controlling forest development in the desired manner. The management design procedures have become decision systems, rather than decision support systems. The planning process has thus become far too rigid, indeed the system dictates the outcome, not just the process of planning.

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Appendix

The following paper entitled "Understanding forest management" was presented at the National Forest Congress in Ottawa April 1986. It is reproduced here as a non-technical introduction to the concept of managing a dynamic resource.

UNDERSTANDING FOREST MANAGEMENT

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ABSTRACT

Silviculture alters the pattern of development in a stand so that the characteristics of a mature stand can be reached in less time than through natural development. Forest management is the control, or regulation, of the pattern of stages of stand development, across the area of the forest, and across time. On-the-ground management control is exercised by temporal and spatial regulation of harvesting, product recovery, silviculture, and protection. Good management is anticipation and correction of emerging structural problems in a specific forest so that the desired quantity and quality of benefits are available continuously. Goodness of management can only be judged in specific cases by comparing what is done on-the-ground against what is needed in a particular forest to achieve the desired goals.

INTRODUCTION

This Congress reflects a rising desire for better management of Canadian forests for greater benefits to Canadian society. Better and greater are nice words, but what do they mean. Better in what way? Greater in what way? The answers to these questions are variable in the extreme. A strong inconsistency has developed between what Canadians seem to want from their forests, and what Canadians as the owners of those forests, have been willing to put into them. Canadians seem to want simple, cheap (free) solutions to problems that they imagine are out there in the forest, but there is an air of unreality in both the imagined problems and the proposed solutions. It should be a major concern that solutions are frequently offered before, or without, any definition of the problems they are supposed to solve. The naive notions of forest management that have emerged in the public domain during the last decade are not consistent with the real nature of Canadian forests.

This session of the Congress deals with the wood supply from Canadian forests, and with what can be done to ensure the continuity of that supply. The key wood supply problem facing Canadian industry is an emerging shortage of reasonable quality raw material at reasonable cost. The shortage is forecast for the coming decades, it is not immediate, and the shortage is of quality wood at reasonable cost, not of wood volume. The question examined in this paper is how can forest management be designed to control the continuous availability of high quality raw material at reasonable cost.

TREES, STANDS, AND FORESTS

A forest is a complex thing to manage by reason of the large size and long time horizons involved. A feature of this complexity is the nested nature of dynamics in both the temporal and spatial dimensions. In the temporal dimension an individual tree has a well-defined life span, while a stand of trees (usually of various species) has a longer, and ill-defined, life span. Forests on the other hand, can go on forever. In the spatial dimension, a forest of 500 000 hectares, although not big by Canadian standards, can be incomprehensible unless this nested nature of the elements of the forest are appreciated and used to enhance understanding. A grasp of tree, stand, and forest level perspectives is basic to an understanding of forest management (Figure 1).

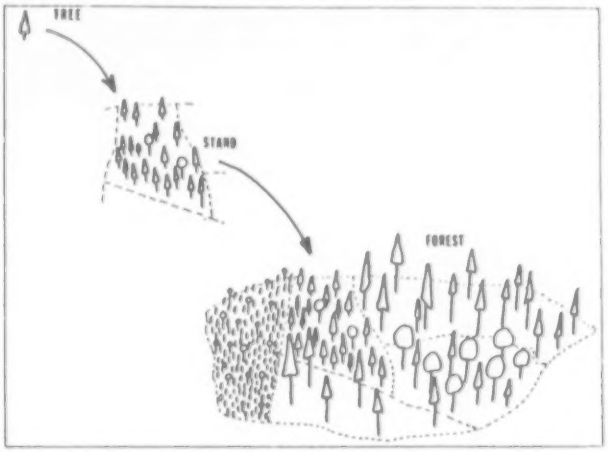

Figure 1. A tree is the basic element of a stand which is made up of many trees of various species competing with each other for survival and growth. A stand is the basic element of a forest which is made up of many stands at various stages of development.

TREE GROWTH

As an individual tree ages it becomes taller, and larger in diameter. These changes occur slowly. A balsam fir in Nova Scotia might pass from seedling, to sapling, to mature tree, to decadency and death, in 90 years. A douglas fir in British Columbia might take 400 years to pass through the same stages, and would reach a much larger size in the process. Whether or not a tree actually passes through all these stages, or meets an early demise, depends on the nature of the environment in which it grows. Each tree species has its own growth pattern and competitive characteristics which are genetically fixed. The genetic makeup of most trees in Canadian forests has been

determined over the past few thousand years of evolution. Except in a very few cases planted trees, with modified genetic quality, represent less than one percent of all the trees in any forest in Canada.

STAND DYNAMICS

While the growth characteristics of an individual tree are important in the sense of how that single tree could grow potentially in the absence of competition, far more important is how that tree actually does perform in a stand made up of many trees, with a variety of species, where there is competition for sunlight and soil nutrients. A stand is a community of trees growing together on a relatively small area (up to a few hundred hectares) and generating a community growth pattern.

Commonly a stand takes form after a disturbance, and starts with a variety of species. The species mix in each case depends on the type of stand that existed before the regenerating disturbance, on seeding from neighboring stands that were not affected by the regenerating event, and on the nature of the disturbance itself. With the passage of time, trees of the various species in the stand grow and compete with one another more intensively. Some trees survive and grow at or near their genetic potential, some survive but with growth rates well below their genetic potential, and some die as a result of being unsuccessful in competition. The character of a stand in terms of species mix, size structure, and canopy structure changes over time, reflecting the results of this inter-tree competition. As the trees become larger, they also become much fewer in number, it not being uncommon for 200 000 seedlings to begin on a hectare with only 1000 surviving to become mature trees. Thus as a stand ages, the average tree size increases, the total number of individuals decreases, and the species mix changes, all as a result of growth and competition (Figure 2). Finally, a stand begins to break up because the trees reach physiological maturity for the component species. At this overmature stage the stand is particularly susceptible to being regenerated suddenly by a windstorm or by attack from insect or disease.

The developmental changes in a stand over time alter the value of the stand for either industrial or wildlife use. Stands are not suitable for harvest until they have reached a certain minimum volume per hectare, and until a certain minimum average tree size has been achieved. The acceptable volume and average tree size depends on the raw material being sought. Where the harvest is raw material for lumber manufacture, the stand must be much older and the trees much larger than is necessary for pulpwood. Thus, the value of a stand as a source of raw materials for a particular industry varies with the species mix, the volume per hectare present, and the average tree size, all functions of the stage of stand development. While stand value is often expressed as a function of the age of the stand, it is important to understand that it is the structural characteristics of the stand that render it fit, or unfit, as a source of raw materials, and not its age. Depending on the type of disturbance that initiates the new stand, the combination of species in the previous stand, the site quality, and intensity of competition, a stand on a particular land area may be suitable for harvesting 50 years after regeneration, or it may take 200 years for stand development to reach the same species mix, and size characteristics.

The natural changes in a stand over time also influence the utility of the stand as a source of habitat for wildlife species. As a stand develops and its structural characteristics, (eg., species mix, canopy form, and density) change, the value of the stand to wildlife will also change. For example, in its very young stages a stand may provide suitable summer feeding for deer, but it is of little value to deer in terms of winter food and cover. By contrast, when the same stand matures it offers very little in the way of summer food for deer, but does provide winter food and cover. For any wildlife species there will be times in the life span of a stand when the stand offers suitable habitat, and times when it does not.

For any use of a stand, whether it be for pulpwood, deer habitat, veneer logs, warbler habitat, etc., etc., there is a time window in the life of the stand when it possesses a structure that renders it suitable. Some of these time

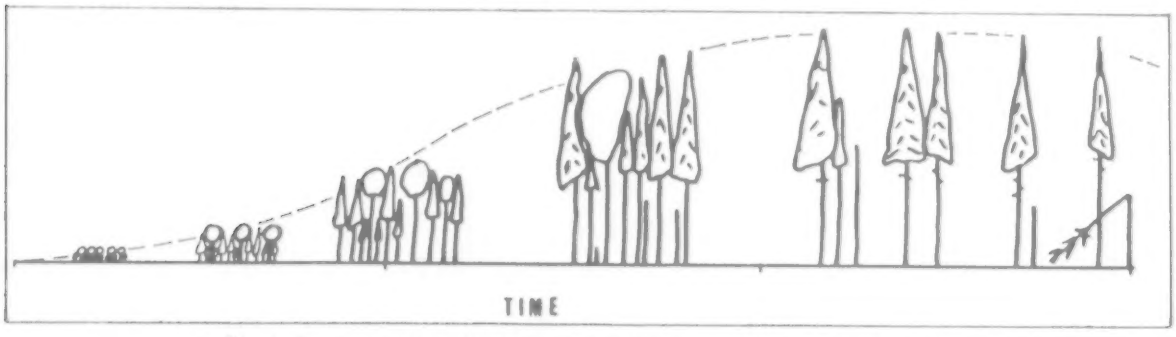

Figure 2. As a stand develops, growth and competition result in larger trees, greatly reduced numbers of trees per hectare, and a changing species mix and canopy structure over time.

windows are narrow, others are wide. Time windows for quite different benefits often overlap. Because stand characteristics change over time as a result of natural development, a stand is not continuously suitable as a source of a particular industrial raw material, or as a source of a particular type of wildlife habitat. Therefore continuous maintenance of either an industry that feeds on a forest, or of a wildlife population that feeds on a forest, requires that stands at different stages of development always be present over an area of forest that is reasonable with respect to access by the user populations, whether these are populations of mills, or populations of wildlife species.

FOREST DYNAMICS

Much as a tree is one element of a stand, so a stand is one element of a forest. A forest contains many distinct stands, whether these are distinguished as one type of stand folowing a single developmental pattern, but with each stand at a different stage of development, or as different stand types with stands at different stages of development. The size of a forest is arbitrary, but they are usually large containing many stands, a common size identified for management in Canada being of the order of 500 000 hectares, although units as small as a woodlot, 50 to 100 hectares, can be the basis of management. The important point here is that a forest contains more than one stand, and therefore exhibits a variety of stand conditions across its area at any one time. At one point in time in a forest there may be a half-dozen different stand development types, with some stands that have recently been regenerated, some that are mature, and stages of development in between. The actual mixture of stand types, and the stages of development, present in a forest at one time, depends on the history of that forest, both with respect to past natural regenerating events, and with respect to past interventions by man.

Because each stand in a forest changes over time as a result of its natural development, the structural character of a forest changes over time, even when there is no intervention by man (Figure 3). For example, without intervention, a forest with 20% of its area supporting immature stands will have that same proportion of the land area supporting mature stands with the passage of a few decades. Also in that time the stands that are presently mature will have passed to over-maturity. The spatial pattern in a forest changes over time in a predictable mannner, driven by development of the component stands.

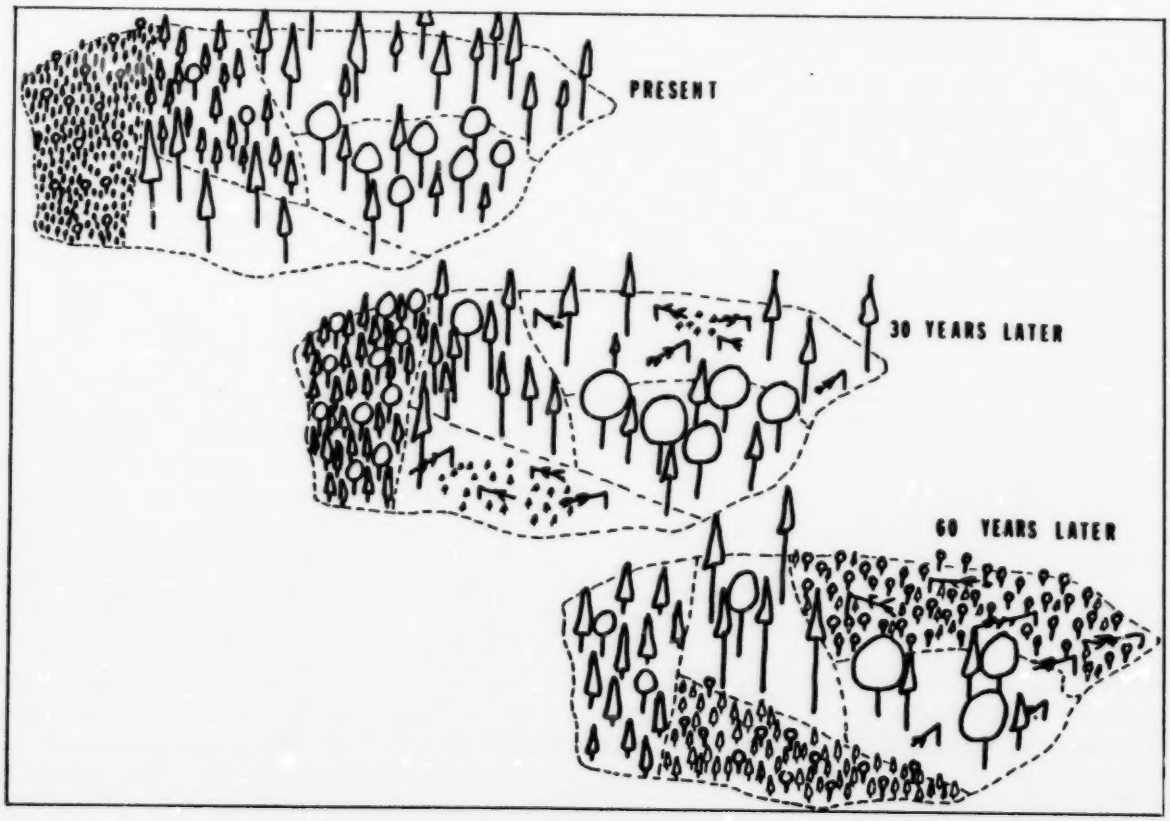

Figure 3. The pattern of an unmanaged forest changes over time as a result of developmental changes in its component stands.

STAND SILVICULTURE

Silviculture is an intervention to alter stand dynamics, either to enhance the development of an established stand, or to create a new stand. In both cases the effect of silvicultural treatment is to cause the future developmental pattern of the treated stand to differ in some particular way from the natural pattern. Most silvicultural treatments operate to speed up stand development so that the conditions of a more mature stage of development can be reached in less time than would be the case under normal conditions.

ENHANCING AN ESTABLISHED STAND

Pre-commercial thinning of natural regeneration is one example of silviculture applied to enhance the development of an established stand. Where natural regeneration from advance growth, or from post-cut seeding, is dense, the rate of development of the stand is slowed down. In this case, the competition necessary to reduce the number of trees per hectare to a range consistent with the increasing size of the trees, is extreme and must operate over a long period of time to achieve the needed reduction in density by natural means. Also over this time competition alters the species mix as the stand develops. Pre-commercial thinning, or spacing as it is frequently called, speeds up stand development by intervening to reduce the number of stems per hectare, and to alter the species mix, in the very early stages of development to a range near that expected at maturity. This allows the remaining trees to grow at rates nearer to their genetic potential.

Spacing natural regeneration captures the benefits of both the seedlings that regenerated from the locally adapted natural stock, and the early start these seedlings had following the harvesting. Spacing speeds up stand development so that the stand structure including species mix, stand volume, and average tree size, characteristic of a mature stand can be reached in perhaps one-half the time of natural development (Figure 4). Spacing does not increase the amount of wood produced on a hectare, in fact it frequently results in somewhat lower stand volumes at maturity. The advantage of pre-commercial thinning is therefore not to get more wood per hectare, but rather to get the same amount of wood and the same average tree size sooner than would be the case with natural stand development.

The ability to speed up stand development is a powerful tool. For instance, if there is a current shortage of immature stands in a forest, because of historical harvesting by man or by nature, this will result in a shortage of mature stands at some time in the future. Current young stands can be pre-commercially thinned so that they reach the characteristics of mature stands sooner, thus helping to balance the availability of the stages of development over time in the whole forest.

CREATING A NEW STAND

The best known silvicultural tool is planting which is used to speed up natural sucession and to alter the species mix on an area. In this case natural post-harvest vegetation development is prevented, and a new stand is created by planting. The planted stand offers the advantages of species control, and of genetic control since it is possible to produce the seedlings for planting from genectically improved stock. Planting also captures some of the advantages of spacing since stand density is controlled. Established plantations grow faster than natural stands because of the regular spacing, and improved stock from the very beginning. Therefore it is not uncommon to expect planted stands to reach volumes per hectare double that of natural stands, and to do so in much less time. Planting thus shortens the time to availability for a particular level of stand volume, and also increases the maximum stand volume that can be achieved (Figure 5). In planning the temporal and spatial control of a forest, planting is used where natural sucession will not lead to timely development of a useable stand and, where it is necessary to get more total volume over time from a limited area of forest.

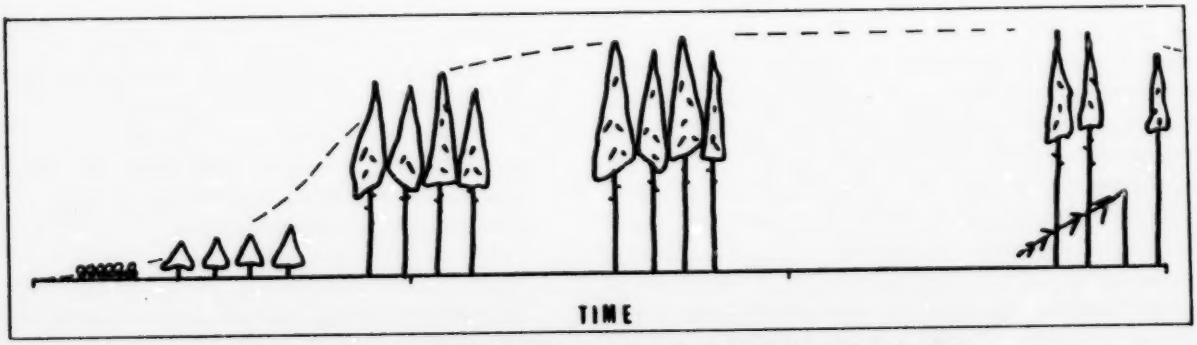

Figure 4. Pre-commercially thinning natural regeneration reduces stand density and alters the species composition at an early age. This allows the residual stems to grow more rapidly and the stand reaches a 'mature' condition sooner. Compare to Figure 2.

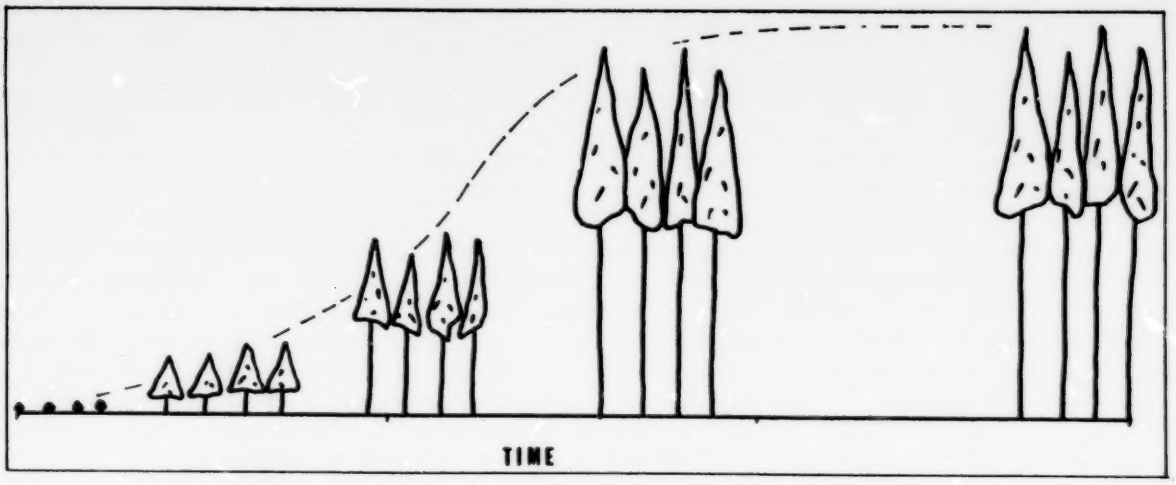

Figure 5. A plantation of genetically improved stock can reach greater volumes than a natural stand. Compare to Figure 2.

Planted seedlings undergo a sharp change in environment when planted, and they are susceptible in the first few years to competition from the pioneer species that naturally invade cutovers. This competition retards the growth, and can cause mortality among the planted seedlings. To get the two values of plantations, more wood per hectare, and at an earlier age than in natural stands, it is usually necessary to weed the pioneer vegetation from a plantation once or twice in the first ten years of its life. After that time the planted trees will normally dominate.

REGENERATION AND HARVESTING

Most of the softwood stands being harvested today regenerated as a result of some natural disaster such as fire, windstorm or insect outbreak. These catastrophes are the natural way of regenerating a stand, and the species of the Canadian softwood forest have become genetically adapted to survive, and thrive, with the help of these rather widespread natural disasters.

The stands currently of harvestable age in Canadian forests strongly reflect the occurance and extent of past natural regeneration events. For example, much of the softwood forest of New Brunswick is currently made up of fir-spruce stands that are mature or near mature. This results from a spruce budworm outbreak in 1913-19 that extended over most of northeastern North America, and which regenerated most of the maturing fir-spruce stands in the New Brunswick forest by killing them in those few years. Balsam fir has adapted with the spruce budworm over evolutionary time, and fir regeneration is a natural event when a fir stand is destroyed by budworm. As a result, a high proportion of the fir-spruce stands in that province are currently mature.

Similarly, extensive areas in northern Ontario support black spruce stands, at a variety of stages of development, as a result of the prevalence of wildfire in the past. Black spruce has adapted to regenerate after fire over evolutionary time. The lodgepole pine stands that lend a particular beauty to the east slopes of the rockies, and to the parks there, also originated following large wildfires, as this species is also fire adapted. As a result of these natural mechanisms of renewal forests tend to have large areas of stands that are all at one age, or in a narrow range of ages, because the events that trigger regeneration in the natural world tend to be cyclical in nature. The periodicity of high risk fire weather is an example.

Clear cut harvesting has the effect of re-initiating stand development, much as natural catastrophies do, but on a more local scale. As with natural regenerating events, the post-harvest development of a new stand depends on the nature of the disturbance (there are hundreds of different logging methods in use in Canada) the nature of the stand that was there before, and the site. Sometimes logging results in slower development of the desired species in the new stand because the disturbance has eliminated the seed source or resulted in increased competition. Sometimes logging results in rapid regeneration of desired species because the disturbance has released an advance growth of seedlings that was already present and suppressed by the main stand. The response to logging in terms of post-disturbance development is one of the most difficult things there is to forecast in forest management because of the large number of potential combinations of site, original stand conditions, and disturbance type.

It is rare for harvesting to result in the elimination of vegetation. Although that does happen, it is not common except on roadways built for logging. The common case is for clear cut harvesting to result in an eruption of pioneer species whose regeneration strategies have evolved so that they literally lie in wait for a natural catastrophe.

Examples are the buried seed strategies of raspberry and pin cherry. These species inundate softwood cutovers the same year as the harvest in much of eastern Canada by germination of seed that has lain buried in the forest floor for many decades. Pioneer species commonly have rapid initial growth and enjoy a few decades of dominance during which time they amply restock the seed supply in the forest floor in anticipation of the next catastrophe. These pioneer species appear to take over the site, but their adpatation in evolutionary terms has left them competitively weak, short lived, or both. This can give stand development a cyclic character. For example, a fir-spruce stand is harvested and appears to regenerate to raspberry, pin cherry, birch, and red maple. With time, balsam fir and spruce seedlings which were on the ground at the time of the harvest, or which have seeded in since, gradually outgrow the pioneer species and literally crowd out those less competitive species from below. The final result at maturity is another fir-spruce stand, but delayed by the interlude of joint occupancy with the pioneer species.

Not all clear cut harvesting results in the timely development of a new stand, nor does all clear cut harvesting result in the absence of suitable regeneration. Each harvest is a unique event, and the post-harvest development depends on the type of stand that was cut, its stage of development at the time it was cut, the site, and the logging equipment used.

FOREST MANAGEMENT

A forest is a dynamic continuously changing thing. The component stands each have their unique developmental pattern determined by a set of conditions, one of which is intervention by man. Forest management tries to control the way the whole forest develops, both temporally and spatially, so that the pattern of stands over the whole forest is continuously suitable for the purposes of management. To successfully maintain an industry based on a forest, management must regulate the development of the stands in that forest so that there are <u>always</u> stands at the right stage of development and in sufficient number to yield the desired raw material mix, in both quantity and quality. Management is therefore very much concerned with regulating the structure of the forest as that is expressed in the proportion of the stands in the forest that are at each stage of development for each stand type. Management must control not only the timing of availability for harvest, but also the location of the stands available for harvesting. This is necessary in order to regulate wood costs, and in order to reduce the risk of losing all of one (any one) stage of development to natural disaster, since such a loss would inevitably mean a break in the future flow of stands at the right stage of development. Management must be based on very long term considerations because problems must be foreseen and treated in time to allow for the slowness of tree and stand growth response.

The problems of managing a forest for wildlife habitat are precisely the same as for wood supply. In the case of wildlife habitat, the forest pattern must be controlled so that there is, at all times, a suitable mix of habitats available. That means that there must always be stands at all stages of development present in the forest. Since stand development results in changes in the habitat value of the stand over time, with or without intervention, forest management aims at maintaining a continuous availability of stands at the required stages by controlling the timing of initiation of stand development. Management of habitat must also control, or regulate, the pattern of these habitats over the forest area where part of the quality measure of habitat lies in the adjacency of habitat types required by the target wildlife species. Management of wildlife habitat availability in a forest is therefore identically similar to management of wood availability. The measures of response are different, but the dependency on control of the temporal and spatial pattern of stand development in the forest is exactly the same.

Because stands change as they develop, it is not possible to have all products, or all habitats, available in one stand all the time. It is possible, by controlling the timing of development in each stand throughout the forest, to have all stages of development, and hence all habitats or products, available at all times in the forest as a whole. This is the essence of forest management (Figure 6).

To manage a forest, for wood or for wildlife habitat, it is necessary to establish measures of suitability with respect to various stages of development in each of the stand types present in the forest. Where there is a spatial element to suitability, this also must be specified in some measurable way. This is the crucial point in understanding the design of forest management. There must be measurable performance indicators so that first, it is possible to determine how, and by how much, the forest structural pattern, as it develops over time, will deliver less than the desired flow of wood or of habitat, second so that a procedure which will rectify the defined problem can be created and implemented, and third so that it is possible to assess the effectiveness of the solution as it is applied in the forest over time. Without measures of what is wanted from the forest, the manager can neither determine the nature of the problem (or even if one exists) nor design corrective measures. Success in managing a forest for any value (wood, wildlife habitat, or whatever) is in direct proportion to the degree to which the value for the target feature has been stated in terms that are measurable on-the-ground at the stand level in units that are relatable to stage of stand development.

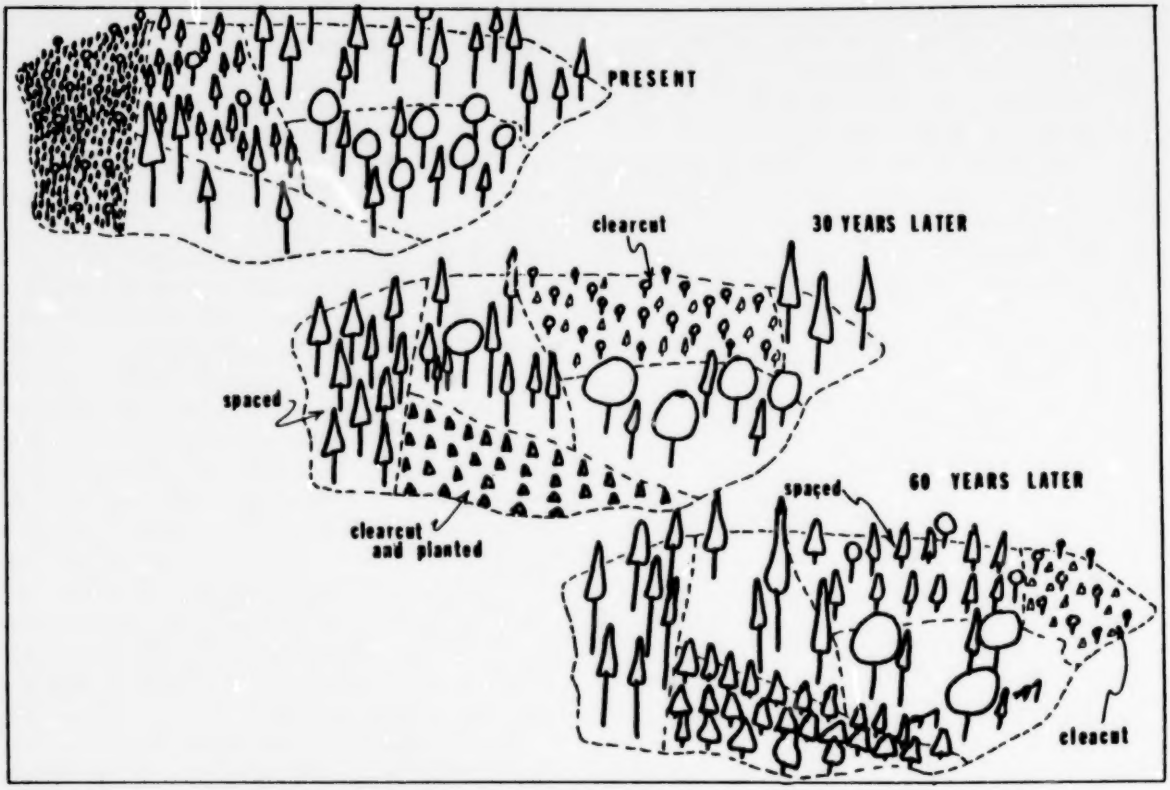

Figure 6. In a managed forest the pattern of stages of stand development is controlled by the timing and location of the harvest, and by treatment. Compare to Figure 3.

TOOLS OF FOREST MANAGEMENT

Forest management is exercising control over the evolving temporal and spatial pattern in a forest so that there is, at all times, sufficient area supporting stands at the stages of development required for all the benefit flows identified for management. Forest management controls the evolving pattern of stand stages across time, and across the area of the forest, by:

(i) determining when and how each stand will be harvested,

(ii) determining what distribution of materials will be taken in each harvest as a stand is actually cut,

(iii) altering actual stand development away from natural patterns by means of silvicultural intervention, and

(iv) protecting (or not protecting) the stands from unexpected harvest such as might be caused by fire or insect outbreak.

These are the necessary and sufficient tools to control the developing temporal and spatial pattern of a forest. These tools are all applied at the stand level to control or regulate the speed and nature of stand development at that local level. The manner in which these tools are applied over the entire forest, and over long periods of time, determines the pattern of stages of stand development that will exist in the forest over time.

SCHEDULING THE HARVEST

Scheduling regulates the amount, timing and location of harvest with the result that the initiation of stand development is controlled in both time and location. Scheduling has two major impacts, first it ensures that there is in fact a sustainable flow of the desired benefits. As long into the future as it is possible to schedule for harvesting stands that have the desired characteristics, then for that period of time there is sustainability. In this respect the basics of management are the same whether the problem is scheduling stands suitable to feed a pulpmill or scheduling stands suitable to feed a deer herd. The second impact of scheduling is that, since harvesting initiates stand development, the time of harvesting is the principal determinant of when, and where, harvestable wood (or usable deer habitat) will be available in the future.

The time and location of the many annual harvest events across a forest determines which stands will begin development from the initial stage again, and consequently determines to a significant extent what will be available at those locations, in terms of the stage of stand development, for a considerable time in the future. Not only does harvest

reset development in a particular stand, but the way in which the harvest is executed influences future development in the new stand, as does the stage of stand development at which the harvest is made. The scheduling of the harvest is the most potent management tool for controlling the temporal and spatial pattern in a forest for future availability of desired stand features.

DETERMINING THE PRODUCT MIX

The forest management need for achieving the best distribution of materials from each stand that is harvested, stems from the fact that there is never enough top quality raw material. While the managed forest will provide an even flow of quality in the long run, there is a chronic problem of consistent quality supply in the wild forest and this will intensify in the medium term during the period of transition from harvesting in wild forests, to harvesting in a managed forest with a structure that has been intentionally chosen and built to consistently provide certain specific needs over time. To design the forest structure that management, over time, will create, and to make the best use of the natural forest as it is brought under management, it is essential to know the various quality needs, and it is essential to achieve the best possible end use of what the wild forest can offer. The default here is high-grading for the best material and leaving the low quality material, which is both wasteful of the resource and, which exacerbates the design problems in forest management.

SILVICULTURE

The silvicultural tools, such as pre-commercial thinning and planting, allow the manager to control the speed and character of stand development by altering the stand structure away from natural trends, or by accelerating natural trends. These tools make it possible to reschedule a stand for the next harvesting at an earlier date than would be possible based on natural development.

PROTECTION

Protection is a key tool of forest management. Use of the other three tools is predicated on the degree of protection that will be maintained in the forest. If no losses to fire, insects, or disease will be allowed, then all the stands in the forest will reach the desired stage of development on time possessing the characteristics that are required. If, as is more likely, fire and insects will make unscheduled harvests of some of the stands in the forest, two problems arise for management. First, it is necessary to allow for the unscheduled harvests so that the total harvest taken, by man and by insects disease and fire, is within the sustainable level for the forest as whole. If fire, insects, and disease are not controlled, or are poorly controlled, there is less available for man. Second, fire, insects, and disease do not harvest in a spatially consistent manner, and they consequently disrupt the forest pattern that is an important element of the management plan. For example, a plan to harvest a forest over a 40-year period with well-placed cut-blocks of 200 hectares each so that the future pattern of the forest will suit some particular management need will fail if fire or insects harvest a single block of 100 000 hectares in one season. The temporal and spatial control of the pattern of stand types, and of their stages of development, that can be achieved in a forest by treating stands in terms of scheduling the harvest, allocating the harvest, and renewal, is only as good as the protection that is provided against unscheduled harvest.

The four tools of forest management, and the way in which they are used to control, or regulate, the unfolding pattern in a forest have binding linkages amongst them. To control forest dynamics requires all four tools. If any one of the tools is not available, sooner of later there will be a loss of management control over the developing forest pattern. This stems from the fact that there is only limited opportunity to trade off more use of one of these tools for reduced use of another. For example, more wood can be made available, with some delay, by increasing the level of planting, but this will not work if the harvest schedule does not (or cannot) stretch the existing stands to last until the plantations become available.

While it is possible to talk about forest management without linking these four tools, it is not possible to implement forest management on-the-ground without facing the powerful nature of their inter-connections. Forest management is the orchestration of these four tools applied at the stand level, to achieve a set of stand level responses, in the context of the whole forest, to result in the forest level response that is sought by management control. At the forest level it is not possible to use one of these tools without the use, or making assumptions about the use, of the others.

Finally a fundamental issue here is that the design of management requires costly information about the forest structure, and the implementation of management, via the four tools, is a costly process. Forest management costs money, and the present condition of the Canadian forests accurately reflects how much money the owners of those forests have, in the past, put into management.

MANAGEMENT IS CONCERNED WITH WHAT WILL BE

It should be apparent from the above that the most crucial thing in forest management is anticipation of the need for specific actions, at specific locations, at specific times. This is challenging in forests, because of the immense temporal and spatial scales involved, and because there is a long time lag between the implementation of an

action and the appearance of the result in the forest structure. It is easy to look back to see what actions should have been taken 30 years ago, in a particular forest, so that the present forest structure would have been capable of delivering a currently desired benefit flow. However, to manage a forest requires a forecast of the temporal and spatial development in a forest ahead 30 years in time, to identify structural problems will prevent the desired benefit flow, and to allow design and timely implementation of solutions. The solutions designed from analyses of such forecasts are specific to the forest in question, its currrent structure, and the benefit flow that is being maintained. The solutions will have both temporal and spatial aspects to them unique to the specific forest. The solutions will be a plan to employ all four tools of management at certain intensities, at certain times, in certain locations, in order to alter the specific forest structure over time in the desired manner.

Forecasting the temporal and spatial development of a forest with various interventions is essential to the design and implementation of planned management. This forecasting is achieved by separately forecasting the development of each of the component stands in the forest at its location and aggregating these into one forest level forecast. Given modern computational power, the procedures for doing this are developing rapidly. Perhaps the principal problem in forecasting for management design is the determination of what measures, or indicators, to use in the forecasts as information to the decision makers. If the measures of effectiveness cannot be specified, then it is not possible to make forecasts useable in the identification of management problems, and it is not possible to identify the action set which, if implemented, would correct the undefined problem.

IDENTIFYING GOOD FOREST MANAGEMENT

Good forest management is control of the temporal and spatial development in a forest so that it is consistently possible to achieve the desired quantity and quality flow of benefits for that particular forest. That sounds like a recursive definition, and perhaps it is, but it is meant to make the point that goodness in forest management does not exist separate and distinct from some stated and measurable objective or standard for the specific forest in question. There is no single prescription, which if followed in all forests, would always be called 'good management'. Planting is often put forth as the universal cure-all, but planting all cutovers in a forest where there is ample natural regeneration is a waste of money, and that is not good management by any definition. Planting, by itself, is a useless measure of management quality. Like any other tool, planting only acquires utility relative to its ability to solve a problem. In forest management the problem is defined by the temporal and spatial character of forest dynamics, and planting is a part of the solution only if it helps solve the temporal and spatial problem in the forest.

There are six features that might be used to assess the quality of management in a specific forest. It should be understood that goodness of management can only be determined in a specific case, and that goodness of management is likely always to be a matter of degree. The features that characterize good forest management are:

1. There is a responsible manager, of a defined forest, with an explicit target forest structure that a management plan is attempting to reach. Given the dynamic nature of the world we live in this will normally be a moving target, therefore there are mechanisms in place for the systematic review of what the target structure should be.

2. There is an analysis of the forest dynamics unique in this forest to define what characterisics of the present structure prevent attainment of the goal structure. Again since the target is moving, and since information on forest dynamics is increasing, there is a mechanism in place for more or less continual analysis in the unfolding future.

3. There is a specific designed solution that is directly referenced to the analysis of the problem. The solution explicitly states the temporal and spatial deployment of the four tools of forest management. There is complete consistency in the way the four tools of management are used with respect to their interdependencies on-the-ground.

4. There is an explicit implementation plan showing what is to be done, where, and when. This is sufficiently explicit to allow realistic appraisal of the cost of implementation.

5. There is an explicit assessment and control procedure in place that is capable of detecting failure of management, whether this derives from pure failure to implement the management plan, or from failure of stands to respond in the forecast manner.

6. There is an explicit procedure in place to initiate redesign of management when failure is detected.

CONCLUSIONS

Canadians can have just about anything they want from their forests if the money for management is forthcoming, and if there is the necessary long-term committment to make management happen on-the-ground out there in the forest. The approach is identical whether the forest is a 50 hectare woodlot or a 500 000 hectare

crown license. The scale problems are certainly different, particularly in aquiring the necessary information for problem analysis, but the principles are identical. In some forests it is just a matter of doing it. In many forests exploitation has driven the structure to a condition where it cannot be fixed without a long period of difficulty. It is these latter cases that occasion the problems of industrial survival during the transition from exploiting a natural forest, to harvesting in a forest that has been managed into a structural form that delivers the desired quality annually.

To ensure progress towards real forest management that closes on real management goals in Canadian forests it is essential that realistic evaluations of forest management be carried out. In particular, it is essential that forest management be examined in the context of specific forests, and not average forests. There is no average Canadian forest, with an average problem, for which there is an average solution. This is equally true in the provincial context. There is no Alberta forest, there are many forests in that province, as there are in any other province. Attempts to characterize all the forests in a province (or the country) in one way, with one problem, and consequently one solution, prevent public (and professional) understanding of the real problems and the variable nature of the real solutions.

Managing a forest means, first of all, managing a biological population, albeit a population of stands, and that means designing management to be consistent with the population structure. That structure is unique to each forest. Summing up how much planting is done, and how many hectares are spaced in a province tells how much money is being spent on those activities, but it cannot tell how much money is being spent on management, nor can it tell how well any of the forests in the province are being managed. While it was appropriate at one time to argue for more money in forest management by using comparative totals, forest management in Canada is ready to move beyond that simplistic level (indeed has moved) and what is needed now is understanding of the real nature of forest management, and of the long-term committment necessary to carry out this complex task effectively in each of the many Canadian forests. If there is one thing about forest management in Canada today that should trouble Canadians, it is that while it is possible to begin to get a measure of silvicultural expenditures, nowhere is there an assessment of management in a forest the meets the criteria stated above. Perhaps this Congress can begin the process of achieving the sort of understanding of real forest management that is necessary to its long-term implementation.